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THE DETERMINATION OF AN OPTIMUM DELIVERY SYSTEM FOR PROVIDING DENTAL CARE TO CHILDREN: A SASKATCHEWAN PERSPECTIVE

by

© KENNETH G. MOORE

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF HEALTH SERVICES ADMINISTRATION

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FALL, 1973

THE UNIVERSITY OF ALBERTA

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ABSTRACT

The provision of dental care to children is becoming a priority within both governmental and private sectors of the economy.

The determination of how dental services may be provided in the most economical and effective manner is the primary objective of this thesis. The accomplishment of this task required an analysis of:

(1) the amount of skill and training required by various dental manpower categories;

(2) the time and cost factors entering into the delivery of dental services using various combinations of dentists and dental auxiliaries; and

(3) several transportation alternatives which would either bring children to the dental service or dental personnel to the children.

The basic conclusions of this thesis are:

(1) The least-cost staffing pattern for providing dental services to children between the ages of three and twelve would include teams of one dental nurse working with two dental assistants in a three-chair clinic. Dentists would carry out the procedures beyond the training of the dental nurse;

(2) Dentists may significantly lower the average costs of the services they provide by employing up to two dental assistants and two dental hygienists able to carry out restorative procedures; and

(3) The least-cost transportation alternative for ensuring accessible dental care in Saskatchewan would involve the establishment of:

a) portable dental clinics in schools where space is available; and
b) centrally located permanent clinics within areas of relatively high population density.

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CHAPTER I

INTRODUCTION

> Thus, our first conclusion is that a thorough study of all dental care needs, of alternative methods of caring for each need, of related job functions, and of the ability of various dental care personnel to perform these job functions is required before the optimal mix of dental care resources can be determined.[1]

The need for and the importance of a dental care program for children has been emphasized many times since 1964, when the Royal Commission on Health Services gave such a program one of the highest priorities of all its proposals to improve the health of Canadians.[2]

By age 13, the dental health of Canadian children has deteriorated to the point where 70 percent of them have untreated caries defects--each child with an average of 2.85 teeth needing restoration. Over six permanent teeth are decayed, missing or filled; 52 percent of the 13-year olds have poor oral hygiene; 27 percent have abnormal gingiva and 65 percent abnormal occlusion.[3]

Governments at both the Federal and Provincial levels in Canada

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[1] R.D. Fraser, Selected Economic Aspects of the Health Care Sector in Ontario, A Study for the Committee on the Healing Arts, 1970 (Toronto, Ontario: Queen's Printer, 1970), p. 155.

[2] Report of the Royal Commission on Health Services, Vol. 1, E. Hall, Chairman (Ottawa: Queen's Printer, 1964), p. 35.

[3] "Canadian Dental Association Dental Health Plan for Children," W.P. Munsie, Chairman (unpublished Task Force Report to the Board of Governors of the Canadian Dental Association, 1968), p. 3.

are already involved in providing dental care under the Canada Assistance Plan. Under this Plan, the Federal Government cost shares 50 percent of the expenses incurred by the Provinces in providing dental care to social assistance beneficiaries. The extent and level of care to be covered is determined by provisions under their respective social assistance programs. As an example, in 1970-71 the Province of Saskatchewan paid out a total of $298,936.00 for 34,830 children between the ages of 1 and 19 who received dental treatment under the Saskatchewan Assistance Plan.

Various other dental care programs for children are being operated by provincial and municipal governments, ranging from a simple school educational program to a fully insured dental service.[1]

The Government of Saskatchewan was the first provincial government to promise a comprehensive dental care program for children.[2] The program is to begin in 1974, and a preliminary plan has already been designed by the government.[3]

---

[1]No province presently provides comprehensive dental services for all its children; but at a lower level of government, such as in the Swift Current Health Region in Saskatchewan, a fully insured public program for children exists.

[2]New Democratic Party of Saskatchewan, New Deal for People (Regina: Service Printing Company, 1971), p. 13.

[3]Research and Planning Branch, Department of Public Health, Saskatchewan, A Proposal for a Dental Program for Children in Saskatchewan (Regina: Saskatchewan Department of Public Health, 1972).

In the private sector, ". . . prepaid dental care is a widely discussed new employee benefit in management and labour circles."[1] "Several powerful unions - the United Steelworkers of America and the United Auto Workers for example - have recently won dental benefits in Canada, with the employers paying 100 percent of the premiums."[2] For those people outside of such unions there are expanding voluntary dental prepayment plans organized by both private insurance companies and the dentists themselves.[3]

Any agency planning on the provision of dental care services will be interested in examining:

1. The need for dental care among specific age groups.
2. The costs of providing required dental services through private dentists or combinations of salaried dentists and auxiliary personnel.
3. Average utilization rates depending upon the accessibility of the services.

Many other factors will of course enter into the provision of comprehensive dental care, but with rapidly rising dental fees,[4]

---

[1] Roger L. Ellis, "A Study and Appraisal of Developments in Voluntary Dental Prepayment and Insurance Plans in North America" (unpublished Master's Thesis, University of Toronto, 1970), p. 40.

[2] Basil Jackson, "Look for Dental Care in Unions' Demands," Financial Post, August 12, 1972, p. 1.

[3] Roger L. Ellis, "Voluntary Dental Prepayment and Insurance Plans in North America," p. 52.

[4] The rise in dentist's fees for the year ending April 1970 was 6.8 percent compared to an average annual rate of insurance of 5.5 percent over the previous ten years. The 5.5 percent rate was the highest among the health care components indexed by the Canadian Federal Government in the Research and Statistics memo by the Department of National Health and Welfare, Health Care Price Movements in Canada, April 1961 to April 1970 (Ottawa: Queen's Printer, 1970), p. 5.

determining an optimum or least cost method of providing the necessary services will no doubt be an area of prime interest for any government or private agency.

Purpose

The purpose of this study will be to determine the optimum dental care delivery system for children in the Province of Saskatchewan. The optimum mix of dental services required for children will not be determined. Instead, the fairly comprehensive list of services proposed in the Saskatchewan Dental Plan[1] will be used to determine the optimum method for delivering these services. For the purposes of this study, optimum will be defined as the least cost alternative which meets certain quality, accessibility, and acceptability criteria.

Format

The study is divided into four main sections. Chapter II contains: a description of the economic framework relating the production of dental services to the determination of a least cost method for providing these services; a description of the role which various types of dental auxiliaries may play in the provision of dental services; and a review of various dental productivity studies. In Chapter III, the empirical data from Chapter II is used in order to both formulate the costs per child for providing dental care and determine the least cost option. Chapter IV includes an analysis of

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[1]Research and Planning Branch, Department of Public Health, Saskatchewan, A Proposal for a Dental Program for Children in Saskatchewan (Regina: Saskatchewan Department of Public Health, 1972), p. 7. Extensive orthodontic procedures are notably absent from this list.

alternate transportation schemes which may be used to increase the accessibility of dental services. A summary, and the conclusions and recommendations arising from the study are presented in Chapter V. The Appendices incorporate a review of output measures used in dentistry, the legal duties of dental hygienists and dental assistants in Saskatchewan, and a thorough description of a computerized transportation model which is referred to in Chapter IV.

CHAPTER II

PRODUCTION AND COST RELATIONSHIPS IN A DENTAL CARE DELIVERY SYSTEM

Theoretical Framework

The term production, as used in economics literature, includes not only the manufacture of the product or the provision of a service, but anything that contributes to the utility or the desirability of a good or service.[1]

In a simple example of a production process, the amount produced of a product "Q," depends on the amounts of two factors (inputs) employed in the process. The inputs of capital and labour are the two factors of greatest historical importance and may be denoted by "K" and "L" respectively. "The production function is the relationship between the quantities of the inputs used and the resulting output."[2]

$$Q = f(K,L)$$

The output in a service industry may be difficult to define or determine with a readily available aggregate measure. The number of patient visits is a measure of output commonly used in the medical and dental fields, but, as has been pointed out by one author, it is

---

[1] Gene K. Groff and John F. Muth, Operations Management: Analysis for Decisions (Georgetown, Ontario: Irwin-Dorsey Limited, 1972), p. 10.

[2] Ibid., p. 11.

". . . roughly comparable to measuring the output of the automobile industry in terms of the number of cars produced, without regard to size, durability, performance characteristics, and so on."[1] For the purposes of this study, output will refer to preventive and treatment services rendered by dental personnel. Various aggregate measures will be used with appropriate cautions.

There are a multiplicity of activities describing the relationship between inputs and the corresponding output of a particular dental service.[2] The general classes of inputs which affect the speed and cost of these activities may be listed and expanded upon as follows:

---

[1]Victor R. Fuchs, The Service Economy (New York: Columbia University Press, 1968), p. 116. A further discussion of various output measures used in the dental care field is presented in Appendix A of this thesis.

[2]The set of activities required to produce a given service such as an amalgam restoration can be illustrated by referring to the list of items set out by Harold C. Kilpatrick in his book Work Simplification in Dental Practice (Toronto: W.B. Saunders Co., 1969), p. 30.

Time Factors in an Amalgam Restoration

Labour input: One dentist and a full-time chairside assistant

Activity	Time (Minutes)
Locating instruments (delay)	0.54
Applying topical	0.22
Injection	1.45
Cavity preparation (rotary insts.)	2.46
Bur change	0.45
Hand instruments	0.33
Cavity drying	0.55
Applying matrix and wedge	0.32
Applying linings	0.27
Packing and condensing	1.36
Removing matrix and wedge	0.10
Carving	2.40
Checking occlusion	0.12
Clearing mirror dip (delay)	0.04
Total Working Time	13.41

Capital: This includes buildings, the number of dental chairs and drills, and the type and amount of other dental equipment.

Labour: This includes the number of dentists and auxiliary personnel. Output will be influenced by the mix of personnel, the division of labour among them, and the inherent speed of individuals due to age, training, experience, or motivation.

Management: This factor takes into account the various organizational, technological and patient variables which may affect output. These include: the acceptable techniques or modes of practice in various areas; the scheduling of appointments; the number of missed or late appointments; the amount of patient cooperation; the amount of non productive staff time due to travel, supervision requirements, and the general layout and operation of the practice.

Cost and Optimality

It is necessary to establish the link between the production function and costs in order to determine the basic criteria for economic efficiency -- namely, the minimization of costs for a specified output.

Mansfield states: "The firm's production function and the prices it pays for inputs determine the firm's cost functions."[1]

If we let r represent the rental price for a unit of capital equipment and let w represent the wage of a unit of labour, then the

---

[1] Edwin Mansfield, Microeconomics (New York: W.W. Norton and Company, Inc., 1970), p. 159.

total expenditure for the factors will be:

$$C = rK + wL$$

The problem for the firm is to choose K and L so as to minimize total costs (C) for each level of output (Q).

"It is traditional in the economic theory of the firm to differentiate between the short run and the long run. The distinction to be made concerns the length of time over which the firm has a chance to alter its decisions."[1] If only a short period of time is allowed, it may be necessary for the firm to treat some inputs as fixed, whereas over a longer time period all inputs may be varied.

In terms of expenditures in the short run, the cost of fixed inputs is the same regardless of the level of output, but the cost of the variable inputs changes with their usage.[2] If "C" represents total cost, "Q" output, and "A" the cost of (short run) fixed inputs, the cost function may be written as:

$$C = A + g(Q)\ ^{3}$$

From this function relating total cost to levels of output, the average cost and marginal cost curves may be derived. Average cost is defined as total cost divided by output. Marginal cost is

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[1]Walter Nicholson, Microeconomic Theory (Hinsdale, Illinois: The Dryden Press Inc., 1972), p. 227.

[2]C.E. Ferguson, Microeconomic Theory (Homewood, Illinois: Richard D. Irwin, Inc., 1966), p. 162.

[3]Ibid., p. 162.

the addition to total cost attributable to the addition of one unit of output.[1] If the average cost curve decreases and then increases (traditional "U" shape), it will be at a minimum when the marginal cost is equal to the average cost.[2] This condition will hold true for both short and long run average and marginal cost curves, but the focus of this study will be on the long run situation.

For the purposes of this study the elasticity of costs with respect to output will usually be referred to instead of specific average or marginal cost measurements. "Elasticity is a measure of the strength (or represents the sensitivity) of the response at a particular time of one economic quantity to a small change in another, when there is a causal link between the two."[3] In this case the elasticity of total costs with respect to output will be defined as the ratio of the percentage increase in costs over the percentage increase in output.

As the long run average cost curve declines, the elasticity of total costs with respect to output will be less than 1; when it reaches its minimum point the elasticity will equal 1; and as the curve rises again the elasticity will be greater than 1.[4]

---

[1] Ibid., p. 171.

[2] Ibid., p. 175.

[3] Neil S. Smith, Economics, Commerce and Administration, Vol. 1 (Toronto: Pergamon Press, 1966), p. 72.

[4] Ferguson presents the necessary derivation which proves this condition on page 175 of his book Microeconomic Theory, but not in a way that is readily recognizable. Algebraically the elasticity of cost

. . . contd.

Empirical data for the costs and output associated with dental care delivery indicate that a "U" shapred long run average cost curve may be expected,[1] and elasticity is used in preference to average cost figures because the measurements of output are often different for various studies. Measuring percentage changes instead of absolute amounts allows a comparison between the various dental productivity studies in spite of the different output measures.

Labour Specialization and the Role of the Dental Auxiliary

The basic economic framework to be employed in this thesis has been described, but before examining various empirical studies, it will be useful to review several dental auxiliary categories which will be referred to many times throughout this paper.

Dental auxiliaries include dental assistants, dental hygienists, dental technicians,[2] dental nurses, and Canadian Forces Therapists.

Footnote #4, contd.
with respect to output is represented by $\frac{dc}{\frac{c}{dQ}{Q}}$ or $\frac{dc}{dQ}.\frac{Q}{c}$.

Ferguson shows that at the point of minimum average total costs $g'(Q) = \frac{A + g(Q)}{Q}$, but $A + g(Q)$ is equal to C and $g'(Q)$ is equal to $\frac{dc}{dQ}$. Therefore, $\frac{dc}{dQ} = \frac{c}{Q}$ or $\frac{dc}{dQ}.\frac{Q}{c} = 1$ when average total costs are at a minimum. A similar proof exists for average variable costs or short run total costs.

[1]Empirical data to be presented in Chapter III of this paper will confirm this conclusion.

[2]Dental technicians are usually trained on-the-job to perform services involved in the fabrication of prothesis and appliances. They do not affect output in children's dentistry as directly as do other categories of personnel and for this reason their functions will not be examined in detail.

In each case to be studied, the reduction in the cost of providing dental care is largely due to the efficient use of one or more of these specialized personnel.

Dental Assistant

In 1964 there were no Canadian facilities outside of the Armed Forces where the dental assistant could receive formal instruction on a full-time basis.[1] Prior to that year, training was obtained either from on-the-job instruction or in evening courses offered by local dental societies. Canada now has various technical schools where dental assistants are trained to provide a wide range of services from patient reception to carrying out certain preventive operations under a dentist's supervision. In Saskatchewan and elsewhere the formal training course extends over approximately a 41 week period.

Current statistics were not available on the percentage of dentists employing dental assistants, but as early as 1963 over seventy percent of dentists employed at least one of this type of auxiliary.[2]

Appendix B of this study contains a list of activities which the Saskatchewan dental assistant is prohibited from performing. Generally speaking the Canadian dental assistant is prevented by law from

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[1]For a more complete overview of the training and duties of dental auxiliaries see B. McFarlane's chapter on "Dental Auxiliaries" Dental Manpower in Canada (Ottawa: Queen's Printer, 1965); and Dalton C. Wells' Report of The Ad Hoc Committee on Dental Auxiliaries, Dalton Wells, Chairman (Ottawa: Information Canada, 1970).

[2]Canadian Dental Association, Survey of Dental Practice 1963, (Toronto: Canadian Dental Association, 1963),p. 45. Unfortunately, the published Survey of Dental Practice 1968 did not include such auxiliary statistics.

carrying out any intra oral work other than certain preventive activities, and must always operate under the supervision and direction of a qualified dentist.

Dental Hygienist

Courses for dental hygienists are two years in length at all schools except at Montreal where the training program extends over three years.[1] The dental hygienist performs such tasks as the scaling and polishing of teeth, applying topical fluorides, taking medical histories, and educating the public at large and individual patients on good dental health practices. Because legal restrictions and training have limited dental hygienists to performing duties often easily carried out by a lesser trained dental assistant or secretary, they have sometimes been referred to as ". . . the most over-trained of all health personnel for the responsibilities and duties assigned to them."[2] Experiments are being carried out in some provinces which allow the hygienist to assist the dentist in restorative procedures.[3]

In 1968 the overall ratio of hygienists to dentists was 1:18[4] and the ratio of graduating dental hygiene students to dental students

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[1]Canadian Dental Association, Dental Education Register 1971-1972 (Toronto: Canadian Dental Association, 1972), p. 5.

[2]Leroy V. Heldt, "Expanded Duties for Dental Auxiliaries," The Journal of the Michigan Dental Association, LIV (September, 1972), p. 280.

[3]One example is in Prince Edward Island. This experiment will be more fully described later in this paper.

[4]Report of the Ad Hoc Committee on Dental Auxiliaries, Dalton C. Wells, Chairman (Ottawa: Information Canada, 1970), p. 6.

in Canada in 1971 was 1 to 2.6.[1] Because over 80 percent of all dentists in Canada are under 60 years of age and not expected to retire soon,[2] the ratio of dental hygienists to dentists should decline.

In 1969, a program in Prince Edward Island trained dental hygienists for two months to perform certain restorative procedures in conjunction with a dentist who always prepared the cavity for a filling.[3] It would appear that with a minimum amount of retraining such duties are both within the competence of dental hygientists and make broader use of her extensive education, especially if they are not used for intensive educational functions.[4]

Dental Nurse

The dental nurse undergoes two years of training in such countries as New Zealand and Great Britain[5] in order to perform a limited and defined range of preventive, curative, and educational services.[6] Saskatchewan began a two year training program for dental nurses in September 1972,

---

[1] Canadian Dental Association, Dental Education Register, 1971-1972 (Toronto: Canadian Dental Association, 1972), pp. 9 and 17.

[2] Canadian Dental Association, Survey of Dental Practice 1968 (Toronto: Canadian Dental Association, 1968), p. 10.

[3] R.G. Romcke, The Prince Edward Island Dental Manpower Study, Final Report, July 7, 1972 (Prince Edward Island, 1972), p. 6.

[4] The actual results of dental education will have to be examined more closely in order to determine the effect or benefit derived from present programs carried out by dental hygienists and whether or not other alternatives might be more effective.

[5] For a world overview of the dental nurse type of auxiliary see Sharon E. Myers' article "Operating Dental Auxiliaries," World Health Organization Chronical, XXVI (November, 1972), pp. 511-515.

[6] Ibid., p. 514.

the first such program in North America.[1]

The New Zealand dental nurse normally works without an assistant and provides regular care at six-month intervals for children between the ages of 2½ and 13 years old. Procedures beyond her training or competence are referred to a dentist. She is able to look after between 450 and 500 children a year in a nonfluoridated area and between 700 to 1,000 children per year in places that are receiving fluoridated water.[2] Her productivity is hampered by the use of old fashioned equipment. For example, high speed equipment is only just being considered; most operatories use adjustable wooden chairs and the work is done standing up; and bulk syringes must be used to dry teeth because compressed air is generally unavailable.[3]

The supervision which the New Zealand dental nurse receives from dentists is minimal, with a total of 25 dentists responsible for the supervision of over 1,350 dental nurses.

In England the dental nurse must work under the direction of a registered dentist who has examined the patient and prescribed the treatment to be performed.[4] In the restorative or surgical field she

---

[1]Further curriculum and other details may be obtained from the Saskatchewan Institute of Applied Arts and Sciences, Regina, Saskatchewan.

[2]Jay W. Friedman, "The New Zealand Dental Service: Lesson in Radical Conservatism," Journal of the American Dental Association, LXXXV (September, 1972), 611.

[3]Ibid., p. 613.

[4]General Dental Council, Final Report on the Experimental Scheme for the Training and Employment of Dental Auxiliaries, 1966 (England: General Dental Council, 1966), p. 11.

is only allowed to undertake simple fillings and the extraction of deciduous teeth. A dentist must be on site for supervisory purposes[1] when these procedures are performed.

The exact restrictions which will be placed on the dental nurse being trained in Saskatchewan are not presently known.

Dental Therapist

The dental therapist or clinical supervisor is a special dental auxiliary in the Royal Canadian Dental Corps.[2] The initial training program consists of a 35-week training course extended over a period of several years in order to bring a dental assistant to the level of a "clinical technician" (similar in function to a civilian dental hygienist). A 16-week course is then followed by the clinical technician in order to graduate as a clinical supervisor. This auxiliary is allowed to perform similar tasks to that of the specially trained dental hygienist of Prince Edward Island.

A Review of Dental Productivity Studies

There have already been many reviews of dental productivity studies but only one was found to provide a critical analysis of the

---

[1] This restriction has been relieved somewhat according to the Dental Nurses from Britain working in Oxbow. The dentist may be temporarily out of the office but available by telephone.

[2] K.M. Baird, G.R. Covey, and D.H. Protheroe, "Employment of Auxiliary Clinical Personnel in the Royal Canadian Dental Corps," Journal of the Canadian Dental Association, XXXIII, No. 4, 187.

results obtained in each[1] and none presented a side-by-side comparison of one study with another in order to simplify the evaluation of differences or similarities.

The purpose of this section will be to provide a brief historical review of productivity studies, and then furnish a more detailed tabular presentation of four of the major investigations. The results of these four studies will be used in the next chapter to determine an optimum staffing pattern. The studies covered will be limited to those which provide concrete productivity data in a form which may be used for comparison purposes.

Historical Overview

As early as 1944, Henry Klein, a senior Dental officer in the United States Public Health Service, had documented the increases in dental productivity which could be obtained with the use of multiple chairs and dental assistants.[2] From his mailed survey he found that the number of patients seen in a week could be increased 33 percent by adding one assistant to a one chair, one dentist, operatory. At that time it was estimated that 55 percent of the dentists in the United States employed dental assistants.

---

[1]Robert L. Lathrop, "Expanding the Functions of Dental Assistants; An Evaluation of Suggestions," Journal of Public Health Dentistry, XXVIII (Spring, 1968).

[2]Henry Klein, "Civilian Dentistry in War Time," Journal of the American Dental Association, XXXI (May, 1944), 648.

In 1950 Moen[1] found, also through a mailed survey, that dentists who employed one assistant averaged 37 percent more patients than those without such employees, while dentists employing two assistants averaged 69 percent more patients.

In 1962 a workshop was held at the University of Michigan[2] on the future requirements of dental manpower and the training and utilization of auxiliary personnel. In one case where patient visits per year were used as a productivity measure,[3] a 33 percent increase in productivity was given for one dentist with one full time employee when compared to a dentist with no employees. This corresponds exactly to Klein's findings quoted 18 years earlier.

The University of Minnesota instituted a training program for dental auxiliaries in 1967 which would allow the auxiliaries to perform expanded duties similar to the specially trained hygienist in Prince Edward Island.[4] Experimental teams containing an auxiliary with at least three months of training in expanded duties, a senior dental student, and a trained dental assistant providing traditional chairside

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[1]George E. Waterman, "Effective Use of Dental Assistants," Public Health Reports, LXVII (April, 1952), 390.

[2]The University of Michigan, W.K. Kellogg Foundation Institute, Proceedings of the Workshop on Future Requirements of Dental Manpower and the Training and Utilization of Auxiliary Personnel (Ann Arbor, Michigan: Edward Brothers, Inc., 1962).

[3]Ibid., p. 161.

[4]Louis J. Brearley and Freeman N. Rosenblum, "Two-Year Evaluation of Auxiliaries Trained in Expanded Duties," Journal of the American Dental Association, LXXXIV (March, 1972).

assistance, were compared with respect to productivity and quality of performance to teams containing a dental student and a trained dental assistant performing traditionally delegated duties.[1] The experimental teams performed 33 percent more procedures than control teams with no significant difference in quality. The addition of a second dental assistant to the experimental team resulted in a further increase in productivity of 18.5 percent.[2]

An extensive four-year study of the utilization of dental auxiliaries trained to perform expanded functions was initiated by the Indian Health Service of the United States in 1969.[3] Dental assistants were trained for seven weeks in the performance of such functions as selecting, contouring, placing, and removing matrix bands and condensing and carving restorations of silver amalgam. A team of one dentist with three auxiliaries trained in expanded duties provided 52 percent more services than one dentist and one and one-half dental assistants operating in the traditional manner. The quality of the restorations placed by the auxiliaries was at least as good as that of the dentist.[4]

Four of the most comprehensively reported studies were not included in the above review as they will each be presented in greater

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[1] Ibid., p. 601.

[2] Ibid., p. 610.

[3] Joseph Abramowitz, "The Implementation of a Program for Utilizing Auxiliaries: The Experience of the Indian Health Service," Journal of Public Health Dentistry, XXXII (Summer, 1972).

[4] Ibid., p. 143.

detail and the results used extensively in the next chapter. Many other studies have been carried out which examined the role of dental auxiliaries and their effect on the output of a dental practice, but generally the data has not been as complete as that contained in the following four experiments.[1]

Royal Canadian Dental Corps Experiment

Two studies were carried out by the Royal Canadian Dental Corps examining dental auxiliaries and their effect on the output of a dental clinic. The first study began in June, 1960.[2] Clinical technicians were trained for sixteen weeks in expanded duties which included packing, carving, and finishing amalgam restorations[3] and were then named "Technical Dental Therapists."

The results of stage 5 of this study as found in the final report[4] are depicted in Table 1.

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[1]One other report appears to have given detailed productivity data. In 1962, the United States Navy conducted an experiment to determine productivity increases by using dental technicians trained in expanded duties. The report is reviewed by Robert L. Lathrop in "Expanding the Functions of Dental Assistants; An Evaluation of Suggestions," but sufficient detail is not included in this review for an evaluation nor has it been possible to obtain a copy of the report.

[2]K.M. Baird, G.B. Shillington, and D.H. Protheroe, "Pilot Study on the Advanced Training and Employment of Auxiliary Dental Personnel in the Royal Canadian Dental Corps: Preliminary Report," The Journal of the Canadian Dental Association, XXVIII, No. 10 (1962), 629.

[3]Ibid., 630.

[4]K.M. Baird, E.C. Purdy, and D.H. Protheroe, "Pilot Study on Advanced Training and Employment of Auxiliary Dental Personnel in the Royal Canadian Dental Corps: Final Report," The Journal of the Canadian Dental Association, XXIX, No. 12 (1963), 781.

Table 1

PRODUCTIVITY ANALYSIS OF THE ROYAL CANADIAN DENTAL CORPS' STUDY, 1963

Stage 5 Part No.	Personnel	Accommodation and Equipment	Time Points Per Duty Day	Marginal Percentage Increase in Output[1]
1	1 dental officer 1 dental assistant	1 treatment bay	110.2	-
2	1 dental officer 2 dental assistants	2 treatment bays	151.4	37.4%
3	1 dental officer 2 therapist 2 dental assistants 1 clerical assistant	3 treatment bays (2 fully equipped)[2]	219.4	44.0%

[1]Each percentage increase in output is over the previous stage of the same study unless otherwise noted. This procedure will also be used for the tables which follow.

[2]The third treatment bay contained only that equipment necessary for the therapist.

The second study commenced in February 1964 and terminated in the fall of 1965.[1] The technical dental therapist was renamed a clinical supervisor. The productivity data found in this study is shown in Table 2.

Prince Edward Island Study

The final report from Prince Edward Island[2] is based on a two and one-half year study ". . . to determine whether specially trained dental hygienists, who insert and finish restorations in cavities prepared by a dentist, can increase the productivity of a dentist to an extent that will make them economically worthwhile in a private dental practice."[3] The report includes data from both a dental public health clinic for children and six private dental offices. A summary of the information obtained from the public health clinic is included in Table 3. Data from the private dental offices are given in Table 4.

The Louisville Experiment

This study was conducted by the Division of Dental Health, United States National Institute of Health, to investigate the feasibility of delegating additional duties to chairside dental auxiliaries.[4] "The

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[1] K.M. Baird, G.R. Covey, and D.H. Protheroe, "Employment of Auxiliary Clinical Personnel in the Royal Canadian Dental Corps," Journal of the Canadian Dental Association, XXXIII, No. 4 (1967), 185.

[2] R.G. Romcke, The Prince Edward Island Dental Manpower Study (Charlottetown: Prince Edward Island Department of Health, 1972).

[3] Ibid., p. 1.

[4] Stanley Lotzkar, Donald W. Johnson, and Mary B. Thompson, "Experimental Program in Expanded Functions for Dental Assistants: Phase 1 Base Line and Phase 2 Training," Journal of the American Dental Association, LXXXII (January, 1971), 101.

Table 2

PRODUCTIVITY ANALYSIS OF THE ROYAL CANADIAN DENTAL CORPS' STUDY 1965[1]

Stage	Personnel	Accommodation and Equipment	R.V.U. Per Duty Day	Time Points Per Duty Day	Marginal Percentage Increase in Output	
					R.V.U.	Time Points
Pre-study	1 dental officer 1 dental assistant	1 treatment bay	95.2	72.6		
1	1 dental officer 1 dental assistant	2 treatment bays (1 fully equipped)[2]	114.1	92.9	19.9%	28.0%
2	1 dental officer 2 dental assistants	2 treatment bays (1 fully equipped)	134.8	104.9	18.1%	12.9%
3	1 dental officer 2 dental assistants	2 treatment bays	141.8	110.1	5.5%	5.5%
4	1 dental officer 2 dental assistants 1 clinical supervisor	3 treatment bays (2 fully equipped)	207.2	159.6	46.5%	44.8%
5	1 dental officer 2 dental assistants 1 clinical supervisor 1 clerical assistant	3 treatment bays (2 fully equipped)	191.3	151.6	-7.5%[3]	-5.0%
6	1 dental officer 2 dental assistants 1 clinical supervisor 1 clerical assistant 1 clinical technician	4 treatment bays (2 fully equipped)	255.8	182.0	23.5% from stage 4	14.0% from stage 4

[1] K.M. Baird, G.R. Covey, and D.H. Protheroe, "Employment of Auxiliary Clinical Personnel in the Royal Canadian Dental Corps," Journal of the Canadian Dental Association, XXXIII, No. 4 (1967), 185.

[2] Partially equipped bays contain only the equipment required for a therapist or, in the case of stage 6, a clinical technician.

[3] This decrease was the result of a summer leave period which lowered the demand for services.

Table 3

PRODUCTIVITY AND COST DATA FROM THE PRINCE EDWARD ISLAND STUDY–PUBLIC CLINIC

Phase	Personnel	Accommodation and Equipment	Output Per 5½ Hour Day		Marginal Percentage Increase in Output		Cost Per Unit of Treatment	
			R.V.U.	Time Units	R.V.U.	Time Units	R.V.U.	Time Units
2	1 dentist 1 dental assistant[1]	2 chairs	33.2	189			$4.07	$0.71
3	1 dentist 2 dental assistants	2 chairs	42.2	232	27%	23%	3.58	0.65
4	1 dentist 2 dental assistants 1 extra trained hygienist	3 chairs	75.4	404	78%	73%	2.52	0.47
5	1 dentist 3 dental assistants 2 extra trained hygienists	4 chairs	85.4	545	13%	35%	2.85	0.45
6	1 dentist 3 dental assistants 2 extra trained hygienists	4 chairs	79.4	498	5% from phase 4	23% from phase 4	3.06	0.50
7	1 dentist 3 dental assistants 2 extra trained hygienists	4 chairs	87.6	479	16% from phase 4	19% from phase 4	2.77	0.51
9[2]	1 dentist 3 dental assistants 2 extra trained hygienists	4 chairs	98.2	629	12% from phase 7	15% from phase 5	-	0.39

[1]The dental assistant could be a receptionist in some cases--this is not specified in the report.

[2]Phase 9 involves quadrant dentistry which is not comparable to the dentistry practised in the other phases. In this procedure the dentist works on one quarter or quadrant of a child's mouth during one visit rather than concentrating on one or two teeth.

Table 4

PRODUCTIVITY ANALYSIS FROM THE PRINCE EDWARD ISLAND STUDY-
PRIVATE DENTAL OFFICES

Office	Phase	Personnel[1]	Accommodation and Equipment	Output In RVU's Per Day	Hours Worked Per Day	Marginal Percentage Increase in Output R.V.U.'s
A	1	1 dentist 1 dental assistant	3 chairs	46	N.A.[2]	
	2	1 dentist 1 dental assistant 1 ex. trained hygienist	3 chairs	60	N.A.	30.4%
B	1	1 dentist 1 dental assistant	3 chairs (1 fully equipped)	42	6.3	
	2	1 dentist 1 dental assistant 1 ex. trained hygienist	3 chairs (1 fully equipped)	57	6.3	35.7%
C	1	1 dentist 1 dental assistant	3 chairs (1 fully equipped)	59	6.7	
	2	1 dentist 1 dental assistant 1 ex. trained hygienist	3 chairs (1 fully equipped)	78	6.7	32.3%
D	1	1 dentist 1 dental assistant	3 chairs (2 fully equipped)	50	7.2	
	2	1 dentist 1 dental assistant 1 ex. trained hygienist	3 chairs (2 fully equipped)	68	7.2	36.0%
E	1	1 dentist 1 dental assistant	3 chairs (1 fully equipped)	34	6.4	

. . . continued

Table 4 -- Continued

Office	Phase	Personnel	Accommodation and Equipment	Output in RVU's Per Day	Hours Worked Per Day	Marginal Percentage Increase in Output R.V.U.'s
E	2	1 dentist 2 dental assistants 1 ex. trained hygienist	3 chairs (1 fully equipped)	59	6.4	73.5%
F	1	1 dentist 2 dental assistants	3 chairs	63	8.2	
	2	1 dentist 3 dental assistants 1 ex. trained hygienist	3 chairs	82	8.2	30.2%
G	1	1 dentist 2 dental assistants	3 chairs	N.A.	7.7	
	2	1 dentist 3 dental assistants 1 ex. trained hygienist	3 chairs	N.A.	7.7	50.8%
H	1	1 dentist 1 dental assistant	3 chairs (2 fully equipped)	N.A.	6.8	
	2	1 dentist 2 dental assistants 1 ex. trained hygienist	3 chairs (2 fully equipped)	N.A.	6.8	44.1%
	3	1 dentist 3 dental assistants 1 ex. trained hygienist	3 chairs (2 fully equipped)	N.A.	6.7	55.9% (over phase 1)

[1]Dental Assistants include chairside assistants and receptionists.

[2]N.A. means these figures were not presented in the data given.

research program, extending over a 5½ year period, was carried out at the Dental Manpower Development Centre in Louisville, Kentucky, a dental facility specially designed for the experimental study."[1] A summary of the productivity findings is included in Table 5.

The Oxbow Experiment

On October 1, 1970, a pilot project was established in Saskatchewan to determine the feasibility of utilizing dental nurses to provide dental services for school children.

A 62 by 12 foot, 3-operatory dental trailer had been custom built and was staffed by two dental nurses from Britain, one supervising dentist, three certified dental assistants, and one secretary. Free dental service was provided to those children between the ages of three and twelve living in an area of schools surrounding the town of Oxbow in southeastern Saskatchewan. By October 1, 1972 statistics had been gathered on over 1,260 children who had received one year of initial care and one year of maintenance care through the project. The Oxbow experiment is expected to continue on its second year of maintenance care at least until the spring of 1973.

Productivity data given in the only formal report on the Oxbow study[2] is not presented in a similar manner to the previous studies.

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[1] Ibid., 101.

[2] Saskatchewan Research and Planning Branch, Department of Public Health, A Proposal for a Dental Program for Children in Saskatchewan (Regina: Government Printing Office, 1972).

Table 5

PRODUCTIVITY ANALYSIS FROM THE LOUISVILLE EXPERIMENT[1]

Phase	Personnel	Accommodation and Equipment	Output Per Day[2] Time Units	Marginal Percentage Increase in Output
August 1967 to December 1968	Base line 1 dentist 1 dental assistant plus clerical support and roving assistants	2 chairs fully equipped	242.4	
	Phase 3 Experiment 1 dentist 4 dental assistants in expanded role plus clerical support and roving assistants	8 chairs	540.7	123.1
January 1969 to January 1970	Base line 1 dentist 1 dental assistant plus clerical support and roving assistants	2 chairs	234.3	
	Phase 3 Experiment 1 dentist 3 dental assistants in expanded role plus clerical support and roving assistants	8 chairs available	421.1	80.2

[1]Stanley Lotzkar, Donald W. Johnson, and Mary B. Thompson, "Experimental Program in Expanded Functions for Dental Assistants: Phase 3 Experiment with Dental Teams," Journal of the American Dental Association, LXXXII (May, 1971), 1075.

[2]This is the average productivity for the four dentists involved in each phase.

The information given in the report deals mainly with the amount of time required to complete the treatment needs of children between the ages of three and twelve using the dental nurse type of auxiliary. Output was not measured in either time units or relative value units as in the previous three studies nor were the combinations of operatories or auxiliaries changed throughout the project to date in order to determine if increases in output could be achieved. The value of the Oxbow project to this paper rests mainly with the information provided on the mobile type of dental clinic, and on the average times required to perform the necessary services for children under maintenance care. This particular information will be presented and used in the next two chapters.

CHAPTER III

THE DETERMINATION OF AN OPTIMUM DENTAL STAFFING PATTERN

Each of the dental studies reviewed in the last chapter have shown that the output of dental services in terms of time units or relative value units may be increased through the addition of dental auxiliaries or dental operatories. Without reference to the mix of services provided, it cannot be determined whether this increase was due to a concentration on the specialized services provided by a particular auxiliary, or a general uniform increase in all the dental services required for a normal patient load. The general mix of services was documented in the Canadian Dental Corps, Prince Edward Island, Louisville and Oxbow studies and did not vary greatly between the various stages of each study.[1]

Output measurements must be related to costs in order to determine an optimal staffing pattern. In order to plan for total provincial manpower requirements and costs, they must also be related to the services required per child.

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[1]The mix of services is not in a format which may be readily analyzed and each study has a different methodology for presenting this data. The mix may be determined from page 783 of the 1963 Canadian Dental Corps Study, page 187 of the 1965 Canadian Dental Corps Study, page 15 in the Prince Edward Island Study, page 109 of the Phase I portion of the Louisville Study and Page 1070 of the Phase III portion. The Oxbow experiment was not divided into phases where productivity was studied; however, the mix of services will be presented in a later table to show the incidence of required procedures on a maintenance dental care program.

The Prince Edward Island and the Oxbow experiments were the only two studies which related cost to output, and only with the use of the Oxbow data are total costs and manpower requirements per child able to be determined. These relationships will be applied in this chapter to all four major studies in order to determine inconsistencies or agreements on the selection of an optimum staffing pattern.

Fee-for-Service Costs

Dental care in Canada is generally provided by private dentists on a fee-for-service basis. Before examining the costs associated with various dental staffing alternatives, it is useful to provide an estimate of the costs which might be incurred if private dentists were paid to provide the required services to children on a fee-for-service basis. This calculation could then be used to compare the relative savings to be expected by developing an optimal staffing pattern.

The information required for this estimation was available from the Oxbow data and is presented in Table 6.

It must be noted that the Oxbow experiment does not provide valid statistics for estimating the total dental requirements for children in Saskatchewan. The data used in this chapter from Oxbow relates only to one particular area of the Province; however, it was the best information available which could be used to project dental need. Because children in the study population had relatively little exposure to fluoridated water[1] the number of restorative services

[1] Fluoridation has only been introduced since 1967 in one of the five communities with children in the study population and the effect of this small amount on the children's dental health is considered negligible.

Table 6

AVERAGE NUMBER OF MAINTENANCE DENTAL SERVICES FOR EACH PARTICIPATING CHILD PER YEAR, OXBOW SCHOOL UNIT, SASKATCHEWAN 71-72 AND THE CORRESPONDING FEE FOR SERVICE COSTS USING COLLEGE OF DENTAL SURGEONS OF SASKATCHEWAN FEE SCHEDULE, 1972

Age	No. of Children Eligible (No. of Children Participating) % of Eligible Children Participating	Personnel* Categories	RESTORATIONS (Amalgam) (1) Surface FFS** $8.00	(2) Surface FFS $12.00	(3) Surface FFS $18.00	EXTRACTIONS Deciduous FFS $9.00	Permanent FFS $9.00	X-RAYS Bite Wing FFS $3.50	Peripical FFS $3.00	EXAM Prophylaxis and Topical Fluoride $15.00	Total Fee For Service Costs For Services Provided By A Dental Nurse
3	57 (51) 90%	DN Dec DN Perm D Dec D Perm D A & C	.039	.059		.02		1.29	.90	1	23.41
4	95 (74) 78%	DN Dec DN Perm D Dec D Perm D A & C	.176	.284	.014	.027		1.54	.97	1	28.61
5	111 (96) 87%	DN Dec DN Perm D Dec D Perm D A & C	.281 .01	.771 .052	.021	.125 .01		1.91	1.0	1	38.39
6	153 (138) 90%	DN Dec DN Perm D Dec D Perm D A & C	.254 .13	1.094 .101 .007 .007	.087	.159		1.97	1.0	1	45.30

. . . Continued

Table 6 -- Continued

Age	No. of Children Eligible (No. of Children Participating) % of Eligible Children Participating	Personnel* Categories	RESTORATIONS (Amalgam) (1) Surface FFS** $8.00	(2) Surface FFS $12.00	(3) Surface FFS $18.00	EXTRACTIONS Deciduous FFS $9.00	Permanent FFS $9.00	X-RAYS Bite Wing FFS $3.50	Peripical FFS $3.00	EXAM Prophylaxis and Topical Fluoride $15.00	Total Fee For Service Costs For Services Provided By A Dental Nurse
7	155 (141) 91%	DN Dec	.092	.66	.021	.177		2.0	1.0	1	41.76
		DN Perm	.262	.326	.007						
		D Dec		.007	.014	.014	.007				
		D Perm									
		D A & C									
8	143 (126) 88%	DN Dec	.048	.198	.032	.19		2.0	1.0	1	40.31
		DN Perm	.365	.54	.048						
		D Dec		.008		.056	.008				
		D Perm	.079	.016							
		D A & C	.024								
9	146 (139) 95%	DN Dec	.036	.058	.014	.151		2.0	1.0	1	37.20
		DN Perm	.36	.496	.043						
		D Dec				.079	.022				
		D Perm	.029	.05							
		D A & C	.05								
10	138 (128) 93%	DN Dec		.008	.008	.297		2.0	1.0	1	34.06
		DN Perm	.313	.28	.016						
		D Dec									
		D Perm	.031	.078	.023	.039	.055				
		D A & C	.109								
11	155 (149) 96%	DN Dec				Anterior Restorations				1	34.03
		DN Perm	.336	.322	.054	.007	.168	2.0	1.0		
		D Dec					.013				
		D Perm	.074	.081	.027						
		D A & C	.121								

. . . Continued

Table 6 -- Continued

Age	No. of Children Eligible (No. of Children Participating) % of Eligible Children Participating	Personnel* Categories	RESTORATIONS (Amalgam) (1) Surface FFS** $8.00	(2) Surface FFS $12.00	(3) Surface FFS $18.00		EXTRACTIONS Deciduous FFS $9.00	Permanent FFS $9.00	X-RAYS Bite Wing FFS $3.50	Periapical FFS $3.00	EXAM Prophylaxis and Topical Fluoride $15.00	Total Fee For Service Costs For Services Provided By A Dental Nurse
12	154 (144) 93%	DN Dec		.014	.007		.181		2.0	1.14	1	36.33
		DN Perm	.306	.424	.104	.007						
		D Dec		.007			.028	.042				
		D Perm	.076	.063	.014							
		D A & C	.167									
13	143 (133) 93%	DN Dec							2.0	1.0	1	32.85
		DN Perm	.248	.263	.098	.015	.105					
		D Dec					.030	.015				
		D Perm	.286	.188	.053							
		D A & C	.293									

[1] This data was compiled from computer printouts of information gathered at Oxbow.

Average cost per child $35.66

* D - Dentist & Assistant
DN - Dental Nurse & Assistant
Dec - Deciduous Teeth
Perm - Permanent Teeth
A & C - Anterior restorations and crowns

** Fee for Service

required will probably be lower in a province-wide program.[1,2]

The average fee-for-service cost per child for those services rendered by the dental nurse in Oxbow would be $35.66 per year. The average cost per child for work performed by the dentist in Oxbow is given in the Saskatchewan report as $6.15[3] and it is recommended in the Saskatchewan report that a second exam, prophylaxis and topical fluoride treatment be given each year at a cost of an additional $15.00 per child. Thus, the total fee-for-service cost for a comprehensive dental program for children between the ages of three and thirteen[4] would average approximately $57.00 per year based on the 1972 fee schedule recommended by the College of Dental Surgeons of Saskatchewan.

The Selection of Input Costs

The percentage change in output for various combinations of dentists, dental auxiliaries and dental operatories found in three

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[1]D.B. Ast, et.al., points out that incremental dental care in a fluoridated area is almost half that found in a nonfluoridated area; see, for example his article "Time and Cost Factors to Provide Regular Periodic Dental Care for Children in a Fluoridated and Nonfluoridated Area: Progress Report II," American Journal of Public Health, LXVIII (September, 1967), 1635.

[2]As of December 31, 1970, 34.5 percent of the total population and 54.0 percent of those on piped drinking water were receiving fluoridated water according to the Dental Health Division of the Saskatchewan Department of Health.

[3]Research and Planning Branch, Department of Public Health, Saskatchewan, A Proposal for a Dental Program for Children in Saskatchewan, p. 80.

[4]Only the ages between three and twelve will be used later in this later because of limited data on the thirteen year olds. The difference in terms of average cost per child is only $0.24.

major studies have been reviewed.[1] In order to determine an optimal staffing pattern from the Canadian Dental Corps, Prince Edward Island, and Louisville studies, cost estimates must be made which are consistent, realistic, and allow a comparison to be made between the studies.

Table 7 has been prepared with information gathered from the sources indicated. Where no source is given, the costs have been compiled using information gathered from both personal interviews with dentists and public health personnel working in Saskatchewan.

The Application of Costs to Empirical Data and the Choice of an Optimum

In order to convert total dental staff time to time per child, which may then be converted to costs per child, some estimate of the total average time for each child receiving dental services must be available. The determination of costs per child is necessary to compare the results of the various studies with the fee-for-service costs calculated earlier, as well as to estimate the total funds required for dental services provided to a given segment of the population. Table 8, taken from the Saskatchewan proposal, provides an estimated average of 129.4 minutes or 2.16 hours of care per year for each child between the ages of three and twelve.

If this total time is divided into the average number of chair-

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[1] Because the Oxbow project was a static situation with respect to staff and operatories, no percentage changes in output were recorded. The costs relating to the Saskatchewan Government's proposal based on Oxbow will be estimated after the first three studies are compared.

Table 7

COST ESTIMATIONS FOR SALARY AND OPERATING EXPENSES OF A DENTAL TEAM

Expenses	Annual Cost	Cost Per Working Day (235 Days Per Year)
Salaries[1]		
Dentists	$23,500.00[2]	$100.00
Dental Nurse	9,400.00[3]	40.00
Hygienist in an expanded operating role or clinical supervisor	8,200.00[4]	35.00
Regular Hygienist or clinical technician	7,050.00	30.00
Dental Assistant, or secretary, or clerical assistant	4,700.00	20.00
Other Operating and Depreciation Expenses		
Basic supplies for 1 dentist or dental nurse. 1 dental assistant and 1 operatory	2,350.00[5]	10.00
Incremental supplies expense for each 50% increase in output over that performed by the basic team above	1,000.00	4.00
Rental of 230 sq. feet for basic operatory	700.00[6]	3.00
Rental of 150 sq. feet for each additional operatory	470.00	2.00
Equipment depreciation at 10% of value -- each operatory	700.00	3.00
Depreciation on partially equipped operatory at 10% of value	470.00	2.00
Miscellaneous expense	940.00	4.00

[1]Fringe benefits are included in each salary cost.

[2]The average dentist on salary in Saskatchewan earned $19,000.00 per year in 1968 according to the Canadian Dental Association's Survey of Dental Practice, 1968. A conservative increase of 5 percent per year would bring this figure up to approximately $23,500.00 in 1972.

[3]Brochures issued to dental nursing students in Saskatchewan indicate a starting salary of from $550.00 to $600.00 per month will be offered by the Provincial Government. The salary figure given allows for two or more years experience.

[4]Romcke, Prince Edward Island Dental Manpower Study, p. 45. Remaining salaries were obtained from estimates given through personal interviews with staff members in the Department of Public Health in Saskatchewan.

. . . continued

Table 7 -- Continued

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[5] Ibid., p. 25.

[6] These costs will vary considerably from area to area. Just over $3.00 per square foot per year has been used but in some urban centres over $5.00 per square foot per year would be charged.

Table 8

Gross Annual Chairside Time (In Minutes), per Beneficiary for MAINTENANCE Dental Care[1]

AGE	CATEGORIES*	EXAMINATION AND X-RAYS	PROPHYLAXIS AND TOPICAL FLUORIDE	RESTORATIONS	POLISHING RESTORATIONS	EXTRACTIONS	ORTHODONTICS AND SPACE MAINTENANCE	STAINLESS STEEL CROWNS AND OTHER SERVICES	TOTAL
3	D								--
	DN	18		2.8		0.2			21.0
	CDA		60		6.1				66.1
	Total	18	60	2.8	6.1	0.2			87.1
4	D								--
	DN	18		11.3		0.4			29.7
	CDA		60		7.4				67.4
	Total	18	60	11.3	7.4	0.4			97.1
5	D					0.6		0.1	0.7
	DN	18		27.8		1.7			47.5
	CDA		60		16.7				76.7
	Total	18	60	27.8	16.7	2.3		0.1	124.9
6	D			0.3			1.2	1.3	.2.8
	DN	18		45.0		1.7			64.7
	CDA		60		18.0				78.0
	Total	18	60	45.3	18.0	1.7	1.2	1.3	145.5
7	D			0.8		0.6	2.8	1.8	6.0
	DN	18		38.5		2.0			58.5
	CDA		60		12.3				72.3
	Total	18	60	39.3	12.3	2.6	2.8	1.8	136.8
8	D			4.0		1.4	2.6	3.5	11.5
	DN	18		44.4		2.0			64.4
	CDA		60		13.8				73.8
	Total	18	60	48.4	13.8	3.4	2.6	3.5	149.7
9	D			4.7		1.6	3.2	1.0	10.5
	DN	18		35.8		1.6			55.4
	CDA		60		11.7				71.7
	Total	18	60	40.5	11.7	3.2	3.2	1.0	137.6
10	D			9.8		2.5	0.5	2.0	14.8
	DN	18		24.2		3.5			45.7
	CDA		60		6.5				66.5
	Total	18	60	34.0	6.5	6.0	0.5	2.0	127.0
11	D			11.4		1.2	1.5	10.5	24.6
	DN	18		27.7		1.8			47.5
	CDA		60		6.9				66.9
	Total	18	60	39.1	6.9	3.0	1.5	10.5	139.0
12	D			13.3		1.9	0.7	8.2	24.1
	DN	18		33.3		1.8			53.1
	CDA		60		6.7				66.7
	Total	18	60	46.6	6.7	3.7	0.7	8.2	143.9
Average	D			4.6		1.0	1.1	2.9	9.6
	DN	18		29.5		1.7			49.2
	CDA		60		10.6				70.6
	Total	18	60	34.1	10.6	2.7	1.1	2.9	129.4

* D - DENTIST
DN - DENTAL NURSE
CDA - CERTIFIED DENTAL ASSISTANT

[1]Research and Planning Branch, Department of Public Health, Saskatchewan, A Proposal for a Dental Program for Children in Saskatchewan (Regina, Saskatchewan: Department of Public Health, 1972), p. 13.

side hours worked by the average dentist,[1] a team of one dentist and one dental assistant[2] working in one operatory should be able to treat approximately $\frac{1569 \text{ hours}}{2.16 \text{ hours}}$ = 700 children per year. The cost of this dental team per day would amount to:

Salary Costs		
Dentist	$100.00	
Dental Assistant	20.00	
Other Expenses		
Equipment Depreciation	3.00	
Supplies	10.00	
Rent and Miscellaneous	7.00	
	$140.00	or $47.00/child

The costing information is applied to the Canadian Dental Corps, Prince Edward Island and Louisville studies and presented in Tables 9, 10, 11 and 12. Each study has used a team consisting of one dentist and one dental assistant to calculate base line data, with certain modifications as noted.

Tables 9 to 12 are summarized in Table 13 as to the effect which various dental teams would have on the average cost of treating children between the ages of 3 and 12.

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[1] Canadian Dental Association, Survey of Dental Practice, 1968, p. 160.

[2] The times given in the Oxbow project were based on both the dentist and the dental nurses working with one dental assistant each. The time for the dental nurse to perform specific procedures is assumed not to be different from the time required for the dentist to perform the same procedure. This assumption was based on a comparison of Prince Edward Island time estimates with Oxbow times.

Table 9

1963 CANADIAN DENTAL CORPS STUDY

Stage	Marginal Percentage Increase in Output (Time Points)	Additional Costs Over Previous Stage		Marginal Percentage Increase in Costs	Potential No. of Children Treated[1]
2	37.4%	1 dental assistant	$20.00		700 x $\frac{137}{100}$ = 960
		1 operatory	2.00		
		Supplies	3.00		
		Rent	2.00		
		Depreciation	3.00		
			$30.00	$\frac{\$ 30}{\$140}$ = 21.4%	
2	44.0%	1 clinical supervisor	$35.00		960 x 1.44 = 1390
		1 clerical assistant	20.00		
		1 partially equipped operatory	2.00		
		Supplies	4.00		
		Rent	2.00		
		Depreciation	2.00		
			$65.00	$\frac{\$ 65}{\$170}$ = 38%	

[1]Using 700 children as a base line.

Table 10

1965 CANADIAN DENTAL CORPS STUDY

Stage	Marginal Percentage Increase in Output (Time Points)	Additional Costs Over Previous Stage		Marginal Percentage Increase in Costs	Potential No. of Children Treated
1	28%	Depreciation of 1 partially equipped operatory	$ 2.00		700 x 1.28 = 900
		Supplies	3.00		
		Rent	2.00		
			$ 7.00	$\frac{7.00}{140.00}$ = 5%	
2	13%	1 dental assistant	$20.00		1.13 x 900 = 1020
		Supplies	1.00		
			$21.00	$\frac{21.00}{147.00}$ = 14%	
3	5.5%	Depreciation on one fully equipped operatory and one operatory which was partially equipped	$ 1.00	$\frac{1.00}{168.00}$ = .6%	1.05 x 1020 = 1070
4	44.8%	1 clinical supervisor	$35.00		1.45 x 1070 = 1550
		Depreciation on 1 partially equipped operatory	2.00		
		Supplies	4.00		
		Rent	2.00		
			$43.00	$\frac{43.00}{169.00}$ = 25%	
5	A decrease in output was experienced in this stage due to summer holidays.				

. . . Continued

Table 10 -- Continued

Stage	Marginal Percentage Increase in Output (Time Points)	Additional Costs Over Previous Stage		Marginal Percentage Increase in Costs	Potential No. of Children Treated
6	14% over Stage 4	1 clinical technician	$30.00		1.14 x 1550 = 1770
		1 clerical assistant	20.00		
		Depreciation on 1 partially equipped operatory	2.00		
		Supplies	4.00		
		Rent	2.00		
			$58.00	$\frac{\$58.00}{\$212.00}$ = 27%	

Table 11

PRINCE EDWARD ISLAND STUDY[1]

Stage	Marginal Percentage Increase in Output (Time Points)	Additional Costs Over Previous Stage		Marginal Percentage Increase in Costs	Potential No. of Children Treated
3	23%	1 dental assistant	$20.00		1.23 x 900[2] = 1110
		Supplies	2.00		
			$22.00	$22.00 / $147.00 = 15.0%	
4	73%	1 extra trained hygienist	$35.00		1.73 x 1110 = 1920
		Depreciation on operatory	3.00		
		Rent	2.00		
		Supplies	8.00		
			$48.00	$48.00 / $169.00 = 28.5%	
5	35%	1 extra trained hygienist	$35.00		1.35 x 1920 = 2600
		1 dental assistant	20.00		
		Depreciation on operatory	3.00		
		Rent	2.00		
		Supplies	8.00		
			$68.00	$68.00 / $217.00 = 31.4%	
6,7	Had the same costs as stage 5 but because of lack of work for the second hygienist, the total output was lower. (Only 23 marginal percentage increase in output for stage 6 over stage 4 and 19 percent increase for stage 7 over stage 4).				
9	15% over Stage 5	No factor was increased except supplies expense estimated to be $4.00. This increase in output was due to quadrant dentistry performed.		$ 4.00 / $285.00 = 1.4%	1.15 x 2600 = 3000

[1]Base line costs included expenses for one dentist, one dental assistant and two operatories, or $140.00 plus $7.00 for the rental, depreciation, and supplies of an extra operatory.

[2]Nine hundred children is used as a base line since two chairs were available at the beginning, similar to stage one of the 1965 Canadian Dental Corps Study.

Table 12

LOUISVILLE EXPERIMENT[1]

Stage	Marginal Percentage Increase in Output (Time Points)	Additional Costs Over Previous Stage		Marginal Percentage Increase in Costs	Potential No. of Children Treated
August 1967 to December 1968	123%	4 dental assistants in expanded role - considered equivalent to the expanded role hygienists			2.23 x 1100[3] = 2460
		4 x 35 =	$140.00		
		Depreciation on 2 operatories[2]	6.00		
		Rent for 2 operatories	4.00		
		Supplies estimated at	20.00		
			$170.00	$150.00 / $167.00 = 90%	
		Less 1 ordinary dental assistant	$ 20.00		
			$150.00		
January 1969 to January 1970	80.2%	3 dental assistants in expanded role: 3 x 35.10 =	$105.00		1.802 x 1100 = 2000
		Depreciation on 2 operatories	6.00		
		Rent for 2 operatories	4.00		
		Supplies estimated at	18.00		
			$133.00	$113.00 / $167.00 = 68%	
		Less 1 dental assistant	$ 20.00		
			$113.00		

[1]The baseline costs include two chairs as per the P.E.I. study but also include a roving assistant and clerical support. A total of $147.00 as per the P.E.I. study plus $20.00 for the combined effect of the roving assistant and clerical support will be used as a base line figure.

. . . continued

Table 12 -- Continued

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[2]Actually eight chairs were available but it is assumed that only four would be used. Figures reflect this assumption.

[3]Eleven hundred children are used as a base line since two chairs were available at the beginning along with an equivalent of two assistants.

Table 13

ESTIMATED AVERAGE ANNUAL COSTS PER CHILD FOR A DENTAL TEAM COMPOSED OF ONE DENTIST WITH VARYING NUMBERS OF CHAIRS AND AUXILIARIES

Study	Number of Chairs	Number of Dental Assistants	Number of Clerical Assistants	Number of Extra Trained Hygienists or Dental Assistants	Average Cost Per Day $	Number of Children Treated		Average Cost Per Child
						Per Year	Per Day[2]	
A	1	1	-	-	$140.00	700	3.0	$47.00
B	1	1	-	-	140.00	700	3.0	47.00
B	1 + 1 partial	1	-	-	147.00	900	3.8	38.60
B	1 + 1 partial	2	-	-	168.00	1,020	4.3	39.00
C	2	1	-	-	147.00	900	3.8	38.60
C	2	2	-	-	169.00	1,110	4.7	36.00
B	2	2	-	-	169.00	1,070	4.56	37.00
A	2	2	-	-	170.00	960	4.07	41.80
A	2 + 1 partial	2	1	1	235.00	1,390	5.9	40.00
B	2 + 1 partial	2	-	1	212.00	1,550	6.6	32.00
C	3	2	-	1	217.00	1,920	8.2	26.40
C	4	2	1	2	285.00	2,600	11.0	26.00
C[3]	4	2	-	2	289.00	3,000	12.7	22.80
D	4	1 (equivalent)	-	3	280.00	2,000	8.5	32.80
D	4	1	-	4	317.00	2,460	10.5	30.00

. . . Continued

Table 13 -- Continued

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[1]Each study is coded in the following manner: A = Canadian Dental Corps Study, 1963
B = Canadian Dental Corps Study, 1965
C = Prince Edward Island Study
D = Louisville Experiment.

[2]This is the number of children which could be given all the required treatment in one day. In actual fact, each child will have several appointments spread out over the year in order to complete the required care.

[3]Special "quadrant" dentistry was practiced in this phase.

As can be seen from Table 13, the studies of the Canadian Dental Corps, Prince Edward Island, and Louisville appear to be consistent for similar organizations of chairs and assistants. When converted to average annual costs per child the 1965 Canadian Dental Corps Study and the Prince Edward Island Study are only one dollar apart for a 2 chair and 2 dental assistant type of practice. The 1963 Canadian Dental Corps results are $5.00 higher but this could be due to a lower base line being used for this study than should have been.[1] A $5.60 difference exists between the Prince Edward Island Report and the Canadian Dental Corps Report when the first extra trained hygienist or clinical supervisor is added. The Canadian Dental Corps only increases output by 44.0 percent with the addition of this auxiliary to the team whereas in Prince Edward Island she increased output by 73 percent. The exact reason for this discrepancy is unknown but there are several differences between the two studies which may account for this inequality. First of all, the Prince Edward Island experiment in the public health clinic treated only children between the ages of six and ten, whereas the dentist in the Canadian Dental Corps study had to provide many more procedures other than simple restorations and extractions because he was dealing with an adult group of patients. The Canadian Dental Corps dentist only had 20.8 percent of his time non-productive compared with 36.3 percent of the P.E.I. dentist. The Prince Edward Island dentist

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[1]On page 781 of K.M. Baird's 1963 Final Report in the Canadian Dental Journal, it is stated that for part 2 a second treatment room was fully equipped; however, it is not mentioned whether part 1 contained a partially equipped room in addition to the one fully equipped. In the 1965 study by the Canadian Dental Corps the provision of this partially equipped room alone increased output by 28 percent. Only one operatory was assumed for the 1963 study.

worked a 5½ hour day because of travel time to and from the clinic, compared to a 7½ hour day in the Canadian Dental Corps. In spite of this time discrepancy in favour of the Canadian Dental Corps, the P.E.I. dentist averaged 36.5 surfaces prepared per day, and the Canadian Dental Corps' dentist only prepared an average of 23.3 surfaces per day. It would appear that because the work on children in the P.E.I. experiment was easier and required proportionately more restorative procedures, much better use could be made of the extra trained hygienist in this area to increase output. If the practice of a clinic were restricted to restorative procedures, and the extra trained hygienist could restore a tooth as fast as it was prepared by the dentist, it would be expected that one specially trained dental hygienist could double the output of a dentist. In fact, the dentist in Prince Edward Island averaged over 76 percent more restorative procedures per day with one extra trained hygienist. The Canadian Dental Corps' dentist only averaged 52 percent more restorative procedures with the one clinical supervisor. A lower increase in output was also obtained in the private dental offices in Prince Edward Island when an extra trained hygienist was added without any other increases in staff. Here the increase in output was only between 30 and 40 percent. Several other reasons are given in the Prince Edward Island report for this low increase, but one of the reasons was that the specially trained hygienists spent more time in patient education than the dentists were previously able to do. This patient education was not converted to an output measure and thus the total value of the hygienist to the practice was not calculated.

The teams in the Louisville experiment are estimated to have

higher average costs per child treated than the other studies. This is to be expected if four extra trained auxiliaries are working with one dentist, since at the most, the dentist is probably only able to keep two busy on restorative procedures. It would seem reasonable that the main reason for the extra training and the higher salary predicted for these auxiliaries is because of their ability to increase the output of the dentist directly through restorative and other complex procedures. It must be recognized that those conducting the Louisville experiment were not attempting to determine the optimal team and in fact suggested this area for further study.[1]

Particular note must be made of the latter phase of the Prince Edward Island study where the estimated costs of $22.80 per child is at least $3.00 per child lower than that of any other alternative. Special "quadrant" dentistry was practiced in this phase, the advantages and disadvantages of which seem to favor its use in a public provision of children's dental care in the schools, but perhaps are not so beneficial to private practice.[2]

The optimum dental team in terms of those alternatives presented in the Canadian Dental Corps, Prince Edward Island and Louisville studies

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[1]Stanley Lotzkar, "Experimental Program in Expanded Functions for Dental Assistants: Phase 3," p. 1080.

[2]For a list of advantages and disadvantages see Appendix A of Transactions of the Canadian Dental Association, 1965, p. 22. "Quadrant" dentistry refers to a dentist working on one quarter of the child's mouth at one visit. This procedure may not increase output to as great an extent in a fluoridated area where each child may only require one filling for each quarter of his mouth, and the advantage of being able to complete a great deal of dental work at one time for each child may be lost.

would consist of one dentist, two dental assistants and two extra trained hygienists working out of a four-chair dental clinic. The approximate cost of this team providing dental services to children between the ages of three and twelve would be between $22.80 and $26.00 per child depending on whether "quadrant" dentistry were performed or found useful. Between 2,600 and 3,000 children per year could receive complete dental care from this team. This least-cost alternative was found in the Prince Edward Island experiment and will now be compared with an alternative resulting from the Oxbow experiment.

The Saskatchewan Proposal

The studies carried out in the Canadian Dental Corps, Prince Edward Island, and Louisville did not include an examination of the actual training required to perform preventive dental functions. The traditionally trained dental assistant used in each experiment did not appear to become involved in intra-oral procedures, except in assisting dentists or those auxiliaries trained to perform restorative procedures.

In the Oxbow experiment, it was found that the dental assistants were capable of carrying out such preventive procedures as prophylaxis and topical fluoride applications.

The introduction of the dental nurse able to perform a complete restorative procedure rather than just filling a cavity prepared by a dentist, is another area of dental auxiliary specialization included in the Oxbow experiment but not considered in the other three major studies.

The Saskatchewan proposal included a specialization of functions broken down on the two previous tables derived from the Oxbow experiment. From Table 8, one dental nurse and one dental assistant would require an average of 49.2 minutes to perform the examinations, x-rays, restorations, and extraction services necessary for children between the ages of three and twelve. One additional certified dental assistant would be required to perform the average of 70.6 minutes of polishing, prophylaxis and topical fluoride services.[1] Because this set of preventive services has been mentioned as being particularly tedious by the staff at Oxbow, the certified dental assistants could switch roles occasionally.

With a three-chair clinic, all three personnel could work on the preventive and polishing services for a certain length of time and each average a total of approximately 57 minutes of work per child. For every six such teams, the full time services of a dentist would be required to do that work beyond the scope of the auxiliaries. If the same average chairside time as used previously was employed, each group of auxiliaries could provide services for:

$$\frac{1569 \times 60}{57} = 1650 \text{ children}$$

The costs for such a service in comparison with the other studies would include the following:

[1]Other preventive measures such as the application of fissure sealants may be more beneficial but would probably be an alternative to one of the other services.

	Costs Per Day[1]
Dental Nurse	$ 40.00
2 Dental Assistants	40.00
Equipment Depreciation (3 chairs - 2 fully equipped)	8.00
Rent	6.50
Supplies	20.00
Miscellaneous	4.00
	$118.50
Plus 1/6th of one dentist operating with 1 assistant[2] 1/6 x $140.00	23.50
	$142.00

The number of children per day would be $\frac{1650}{235}$ = 7, and the average cost per child would be approximately $\frac{\$142.00}{7}$ = $20.00.

It is useful to separate the savings attributable to the dental nurse from those obtained by allowing the dental assistant to perform preventive procedures. If a dentist is employed to perform all those procedures proposed by Saskatchewan to be carried out by a dental nurse, the costs of such a team may be compared with the costs obtained in the Canadian Dental Corps, Prince Edward Island and Louisville studies in order to find the cost advantage of using a dental assistant able to carry out preventive work.

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[1]Refer back to Table 7 of this thesis for details.

[2]This is not the optimal combination of dental auxiliaries with one dentist but is based on the work load of the dentist and dental assistant in the Oxbow experiment.

From Table 8, one dentist and one dental assistant would require an average of 58.8 minutes per child to perform all services except prophylaxis, topical fluoride applications and polishing restorations. The second dental assistant would take an average of 70.6 minutes per child to perform her duties. As in the case with the dental nurse, the work load could be split such that each staff member averaged approximately 64 minutes per child.

One dental team composed of one dentist and two dental assistants working in three operatories would thus provide dental care for $\frac{1569 \times 60}{64} = 1470$ children. The costs associated with this team would be approximately:

	Costs Per Day[1]
Dentist	$100.00
2 Dental Assistants	40.00
Equipment Depreciation (3 chairs - 2 fully equipped)	8.00
Rent	6.50
Supplies	20.00
Miscellaneous	4.00
	$178.50

The number of children per day would be $\frac{1470}{235} = 6.25$, and the average cost per child would amount to $\frac{178.50}{6.25} = \$28.60$.

From cost estimations calculated, the optimum dental team would follow the Saskatchewan model of using dental nurses and dental assistants.

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[1] Refer to Table 7 of this thesis for details.

By using dental nurses, between $2.80 to $6.00 per child can be saved (depending on the question of quadrant dentistry) when compared with the costs associated with any of the other alternatives using dentists and extra trained hygienists.

Quality considerations have not been emphasized up to this point. In terms of the procedures delegated to dental auxiliaries, all work was examined by dentists for each of the major experimental projects covered in this paper and no significant quality problems were reported. In the case of the dental nurse in Oxbow, a committee of dentists found the work performed by this auxiliary to be of as high standard as that of a graduate dentist.[1]

A basic dental team composed of one dental nurse and two dental assistants operating out of a 3-chair clinic will be used as the optimum staffing pattern for the purposes of the next chapter. A discussion of the requirement for a dentist for every six basic teams will be related to certain geographic constraints in Saskatchewan which limit the feasibility of the six team, one dentist concept.

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[1]Information from a personal interview with Dr. T. Curry, Director of Dentistry for the Province of Saskatchewan.

CHAPTER IV

THE DETERMINATION OF AN OPTIMUM TRANSPORTATION SYSTEM

In the introduction to this study, statistics were given demonstrating the large proportion of children in Canada who need dental care, but for one reason or another have not obtained the required services under the existing private dentist, fee-for-service system.

Parents may be unable to afford dental services, the dentist may be located too far away, or working parents may not have time to ensure their children visit a dentist. Unfortunately, it is the unknowing child who suffers from this neglect and consideration should be given to ways of maximizing utilization rates for any dental program. Providing free dental services has not been as effective in ensuring a high utilization rate, as might be expected. Only when the service has been taken to the schools or transportation is provided for children to be taken to the service have utilization rates in excess of 90 percent been encountered.[1]

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[1]There is sufficient evidence in the literature to suggest much higher utilization rates when the services are made accessible in this way. Roger Ellis surveys prepayment dental plans in his dissertation "A Study and Appraisal of Developments in Voluntary Dental Prepayment and Insurance Plans in North America" (unpublished masters dissertation, University of Toronto, 1970), and finds most schemes with child utilization rates between 40 and 70 percent, often fluctuating with the occupational class of the parents. A high utilization (excluding broken appointments) of 68 percent (... continued)

In order to determine an optimum transportation system for the delivery of dental care in Saskatchewan, alternative modes of transporting children for dental services must be examined in conjunction with the geographical distribution of the province's roads, children, and existing dental manpower. By ignoring any one of these geographical considerations, a transportation alternative may be chosen which is optimal in terms of being the least cost method of providing the dental services, but which is completely unacceptable from a practical viewpoint. For example, the least cost delivery system might involve locating all dental personnel in one or two geographical centres and transporting all children by bus to these centres. Unfortunately, the choice of this alternative might necessitate children being transported over 300 miles one way to attend one appointment. Parents in rural areas who already feel that their children are spending too much time on the school bus would probably refuse to enroll their children in such a program, and utilization rates would be reduced.

(Footnote #1 contd)
was documented in the pilot year for children participating in the dental care program of the International Longshoremen's and Warehousemen's Union-Pacific Maritime Association (ILWU-PMA); see, for example, the report by the U.S. Department of Health, Education and Welfare, Report on the Dental Program of the ILWU-PMA, The First Three Years (Washington: United States Government Printing Office, 1962), p. 21. In contrast, school based dental programs such as New Zealand's enjoy a utilization rate as high as 95 percent for school children and the Oxbow experiment had a utilization rate of over 90 percent for school aged children. In the British General Dental Council's report, Final Report on the Experimental Scheme for the Training and Employment of Dental Auxiliaries, 1966, p. 13, this statement was made: "One authority has found that if dental treatment is provided in a mobile clinic at a school the acceptance rate is 100 percent, while if children have to visit a central clinic and transport is not provided, the rate falls to 40 percent."

Geographical Framework

The total population of Saskatchewan in 1972 was 934,607[1] distributed over 220,182 square miles of land. The province's eleven cities[2] contained less than 43 percent of the population, with the remainder living in towns, villages, reservations, and on farms. In 1966[3] twenty-two percent of the population lived in unincorporated centres of less than 1,000 persons, and the farm population in that year was 29 percent of the total population. "Population density varies substantially from one part of Saskatchewan to another, the north and southwest having always been sparsely settled."[4]

Schools and School Aged Children

The population of school children in Saskatchewan will decrease rapidly over the next five years. In 1971 there were 20,582 seven year olds, but only 15,827 one year olds in the Province.

Because of the distribution of the population, there is a wide dispersion of schools. In 1972 there were 1,027 schools in Saskatchewan, ranging in size from seven children to over 1,000 children per school. Out of these, over 350 schools had less than

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[1] Saskatchewan Hospital Services Plan, "Covered Population - 1972" (unpublished report for the Department of Public Health, Regina, Saskatchewan, 1972).

[2] Regina, Saskatoon, Moose Jaw, Prince Albert, North Battleford, Lloydminister, Swift Current, Weyburn, Yorkton, Estevan and Melville.

[3] The latest figures available were for 1966.

[4] J. Howard Richards, ed., Atlas of Saskatchewan (Saskatoon: Modern Press, 1969), p. 38.

20 children per grade. The schools are gathered into 60 school units which blanket the Province and provide the transportation necessary for all children within the unit.

Dentists

In 1972 there were 189 active[1] dentists in Saskatchewan, giving an overall dentist/population ratio of 1:5089. Unfortunately, the dentists are poorly distributed, with a population per dentist ranging from 1:2500 for those people living in or close to Saskatoon to less than 1:8000 for those people living in the area surrounding the towns of Wynyard and Wadena.[2]

In order to facilitate a geographic perspective, three maps are included in the following three pages. The first is a road map of the province. Although major centres are all connected with paved roads, there are still a great number of gravel and graded surfaces. The second is an outline of the 60 school units, each containing in total more than 100 children per grade, and the third contains the geographic distribution of dentists in 1971.

A Description of Alternatives

There are basically five alternative methods of either taking the dental service to the schools or the children to the service. These are:

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[1]"Active" includes those dentists employed by the Health Regions, government, and institutions.

[2]Richards, Atlas of Saskatchewan, p. 169.

ILLUSTRATION 1

ROAD MAP OF SASKATCHEWAN

Bituminous Surface Inter-Lane, divided
Bituminous Surface
Oiled Surface
Gravel Surface
Graded
Projected
Municipal Grid Road (Projected)
Municipal Grid Road
Resources Development Road-Gravel
Resources Development Road-Graded
Trans-Canada Highway
SASKATOON
REGINA
1:3,000,000

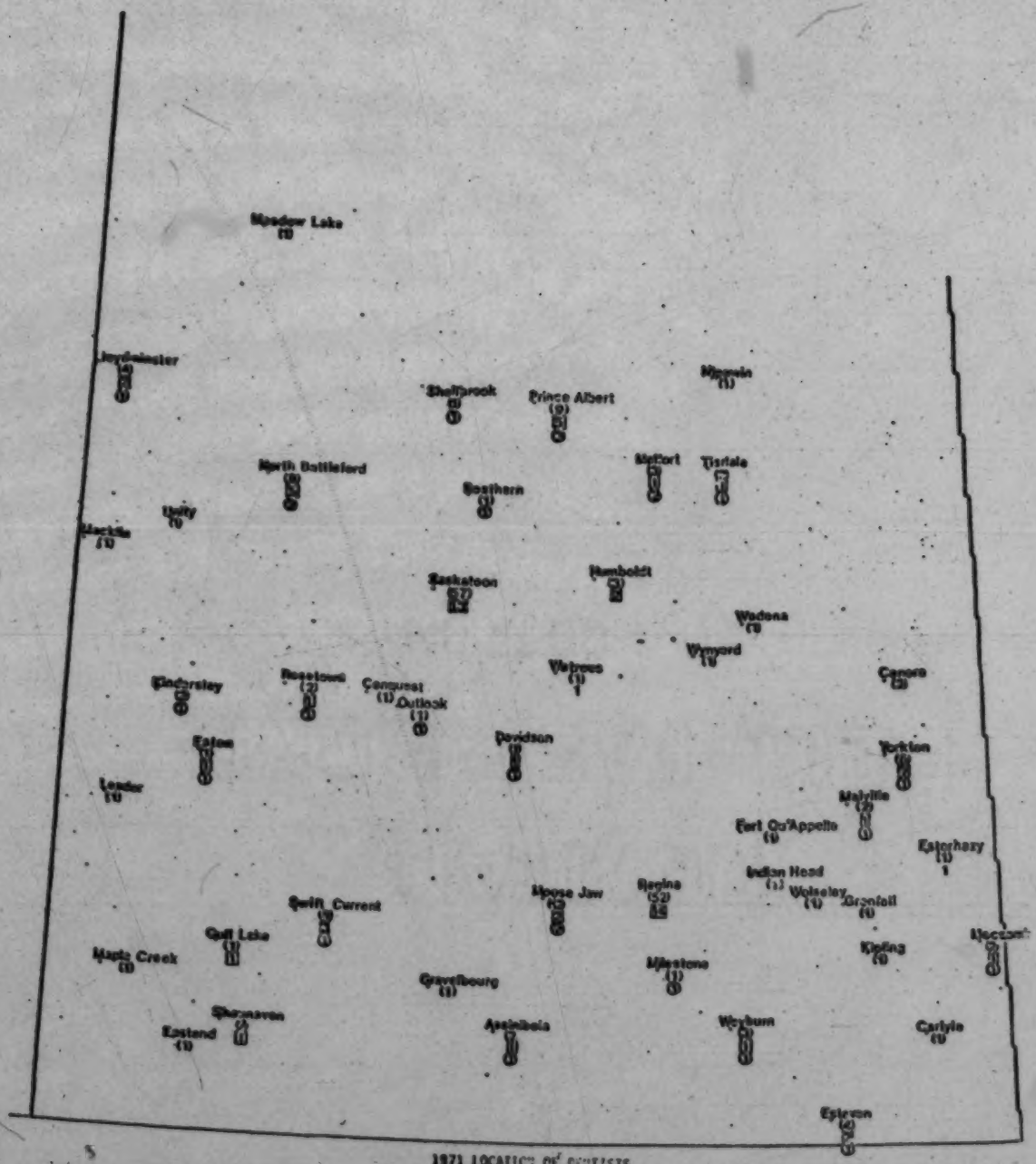
ILLUSTRATION 2

SCHOOL UNITS IN SASKATCHEWAN, 1969

SASKATCHEWAN

ILLUSTRATION 3

LOCATION OF DENTISTS IN SASKATCHEWAN, 1971



1971 LOCATION OF DENTISTS
(1) NUMBER OF DENTISTS
NUMBER OF BURSARY RECIPIENTS
NUMBER OF ESTABLISHMENT GRANTS

Dental Health Division
December 15, 1971

(1) Establish a permanent year-round clinic in or close to the school.

(2) Set up a portable clinic in or close to the school.

(3) Operate a mobile clinic which is set up on a ramp space on the school grounds.[1]

(4) Transport the children to a dental clinic by bus or other vehicle.

(5) A combination of the above four methods.

Each of these alternatives is already being used to some extent around the world, but no comprehensive examination or cost comparison has been found in the literature.

Five mobile units[2] (one railway dental car, one 60-foot by 12-foot highway mobile home and three Red Cross Highway Coaches) are presently providing preventive and basic treatment services to pre-school and elementary school children living in remote areas of Ontario. Each unit has a single operatory staffed by a dentist and a dental assistant. Provision for living accommodation exists on all five units. The highway trailers have been operation for six years, generally making one stop a year at each location and averaging a total of 70 to 100 miles of travel per year over paved roads. The highway trailers had cost approximately $11,500.00 each and dental equipment

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[1] A mobile clinic is defined as a fully equipped dental operatory which may be transported intact by road or rail. A portable clinic is defined as a room within an existing permanent structure such as a school classroom to which the dental equipment required for a complete operatory has been transported and temporarily installed.

[2] A letter concerning these units was received on July 23, 1972, from Dr. R.E. Feasby, Senior Consultant, Public Health Dentistry, Department of Health, 1 St. Clair Avenue West, Toronto 195, Ontario.

for each operatory was an additional $8,600.00. The railway car and annual maintenance services were donated. The interior of the car was rebuilt at a cost of $18,000.00 and dental equipment cost an additional $5,000.00.

The Appalacia II District State Board of Health in South Carolina uses a 10-foot by 40-foot mobile dental clinic with two dental operatories and one dental hygienist's operatory. The mobile unit cost $14,000.00 and the operatories were equipped for an additional $19,000.00.[1]

Both New Zealand and Australia use mobile clinics to some extent but in New Zealand this service is largely being abandoned in favor of permanent clinics built on the school grounds.[2]

The Indian Health Services in the United States also uses fully equipped mobile dental clinics which cost between $35,000.00 and $45,000.00 each.

The Oxbow experiment used a combination of the mobile dental clinic and the transportation of school children by bus to the mobile clinic.

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[1] From a letter mailed on July 18, 1972 by Dr. H.B. Huffstetter, Appalacia II District State Board of Health, Pickens County Division, P.O. Box 323, Pickens, South Carolina, U.S.A.

[2] Information received from a report by Dr. D. Curry, Saskatchewan Director of Dental Health Services, presented to the Department of Public Health of Saskatchewan after a tour of the New Zealand service from July 12, to June 27, 1972.

The Prince Edward Island report mentions that dental clinics were set up in schools.[1] Although some of the equipment may not have been considered portable, in fact much heavier and bulkier equipment is moved by furniture vans every day. Portable chairs and other dental equipment, which is relatively easily carried by two women and transported in a van or station wagon, is available, but no documented evaluation of portable chairs used in a comprehensive dental service was found.

Other areas in Canada and the United States are beginning to look closely at, and experiment with, mobile dental units to service rural areas. Unfortunately, little data has been published on the problems and expenses involved in the provision of this type of service.

In order to determine the optimum transportation system from the various alternative modes of ensuring accessibility among school children, it is of course necessary to examine many factors other than cost which may bring about a decision in favor of one particular alternative. Mobile clinics are limited in size by highway and rail restrictions; portable clinics must rely on existing unused space which may or may not be available in or close to many schools; the establishment of permanent clinics may involve expensive capital outlays for construction in an area where the population shift may no longer justify a permanent clinic in a few years; and as already mentioned, the transportation of children by bus may be extremely unpopular with

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[1] R.G. Romcke, The Prince Edward Island Dental Manpower Study, p. 8.

parents in rural areas who feel their children already waste enough of their time on the bus going to and from school.[1] In spite of these any many other non-economic factors which may enter into the choice of a particular alternative, it is still necessary to estimate what various options will cost for budgetary considerations.

Cost figures appropriate to Saskatchewan will be introduced in the following comparison of delivery options. Each will consider the optimum labor and capital mix to be one dental nurse, two dental assistants, two fully equipped operatories of 100 square feet each, and one partially equipped operatory of 80 square feet. A permanent clinic not located in a school must also have space for a waiting room and a staff lounge area which may bring the total space required to between 530 and 750 square feet.[2]

Table 14 will compare the costs of each alternative type of clinic.

Of the three alternative types of clinics in Table 14, it must be noted that both the portable and mobile clinics may service many separate schools whereas the permanent clinic must either be

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[1]For other considerations to be made concerning mobile sites see Graham Turner's article "Organization in the School Dental Service," British Dental Journal (September, 1971), pp. 283-284.

[2]The Oxbow trailer contained all the above space plus a 7-foot by 8-foot x-ray room and one small staff washroom in a total of 750 square feet. The waiting room was considered too small in the trailer but in a permanent clinic the space for x-rays could be included in one operatory. A total requirement of 750 square feet will be used for both mobile and permanent clinics for the sake of consistency.

Table 14

COSTS OF DENTAL CLINICS

Costs	Mobile Clinic	Permanent Clinic	Portable Clinic
Capital Cost			
Clinic	$14,000.00 - $24,000.00[1]	$9,000.00 - $18,000.00[2]	$ 500.00[3]
Equipment	$18,000.00[4]	$18,000.00	$18,000.00
Estimated life of clinic	10 years	20 years	20 years
Estimated life of equipment	10 years	10 years	8 years[5]
Annual Costs			
Depreciation Per Year			
Clinic	$ 1,400.00 - $ 2,400.00	$ 450.00 - $ 900.00	$ 25.00
Equipment	$ 1,800.00	$ 1,800.00	$ 2,250.00
Utilities	$ 1,000.00[6]	$ 500.00	$ 500.00
Insurance and Licence	$ 300.00	$ --	$ --
Banking and Skirting[7]	$ 300.00	$ --	$ --
Transportation costs	$ 150.00 - $ 600.00[8]	$ --	$ 130.00[9]
Platform or paved surface[10] for each site (estimated)	$ 400.00		
Total Annual Costs, excluding supplies, salaries and lost labor due to travel and set up[11]	$ 5,800.00 - $ 6,350.00[12]	$2,750.00 - $ 3,200.00	$ 2,905.00

[1]Depending upon whether the mobile clinic is self-propelled or must have a truck to move it, the cost will vary from $14,000.00 for a separate trailer to $24,000.00 for a self-propelled unit.

[2]A prefabricated unit runs at $12.00 per square foot in Saskatchewan whereas schools themselves cost between $22.00 and $24.00 per square foot in Saskatchewan. If space is rented, the cost could be $4.00 per square foot per year or $3,000.00 per year for a 750 square foot clinic.

. . . continued

Table 14 -- Continued

[3]This $500.00 would be for the installation of electric and water lines in a portable clinic.

[4]The equipment for 2 complete operatories and one partially equipped for preventive work would cost this amount according to both the Prince Edward Island and Saskatchewan reports. A more expensive chair than that used in the Saskatchewan proposal is recommended due to recent breakdowns of this particular chair in Oxbow.

[5]Due to more wear and tear due to moving, portable equipment would probably not last as long as fixed equipment.

[6]The connection and disconnection of power, water, and telephone lines will cause the costs for the mobile clinic to be higher, depending upon how many stops are made.

[7]A trailer must be levelled and the bottom protected from the cold in winter. This may take 2 men 2 hours at a cost of $7.00 per hour per man or at least $28.00 each time the mobile clinics are moved. A self-propelled vehicle would not need this labor.

[8]A 12-foot wide trailer costs 60 cents per mile one way for hauling. At an estimated 1,000 miles a year minimum travel, this would cost $600.00 per year. A self-propelled vehicle is estimated to cost 15 cents a mile for gas, oil, and engine depreciation or $150.00 per year.

[9]Portable equipment could be transported in normal government vehicles at a cost of approximately 10 cents a mile.

[10]An axle was broken in the Oxbow trailer when it was pulled from soft ground at one location. Because of the experimental nature of the Oxbow program, no surfaces were paved for a platform.

[11]Salary and supply expenses would not differ between alternatives except that labor would be lost in portable and mobile clinic set-ups, and in travel to and from clinics away from the home base. In the Oxbow experiment packing and unpacking took at least one day in total for each move. The labor cost for this is estimated to be equivalent to any set up or take down of portable equipment. A self-propelled mobile unit would probably be the most efficient in terms of set up and take down times but costs more to purchase and has less space available than a trailer unit.

[12]Note that the lowest transportation costs of $150.00 is added to the highest cost self-propelled mobile clinic at $2,400.00 per year depreciation.

combined with a portable or mobile clinic, or children must be transported to the permanent clinic in order to provide the same accessibility. With this fact in mind, it can be seen that a portable clinic would be the least costly of the three alternatives provided space was already available within all the schools to be serviced in this manner.

The question remains as to whether children transported by bus to a portable, mobile, or permanent clinic is less expensive than sending a dental team with portable equipment out to a remote school.

Because so many factors enter into this question, a model was developed and transformed into a computer program in order to save manual calculating time. A description of this model is included in Appendix C of this study. Tables 15, 16, and 17 list a sample of the results obtained from this model.

Transportation costs listed in each of the following three tables are associated with schools containing 10, 100 and 200 children respectively. The costs are a total for a six-month period and an average of two visits per child to the dental team, as explained in Appendix C. Certain fixed costs are involved in setting up a portable dental clinic and for this reason total transportation costs per child are less expensive for servicing a school with 100 children than for a school with 10 children. Transportation costs for buses vary in a linear relationship with the number of miles a school to be serviced is away from the home base of the dental team. A linear relationship is also observed between the costs associated with transporting children by bus and the number of dental teams located in the clinic to which

Table 15

THE FOLLOWING TABLE LISTS PORTABLE UNIT COSTS, AND BUSSING COSTS FOR 10 STUDENTS

NUMBER OF TEAMS

MILES		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	PC	56.40	112.40	168.30	224.20	281.20	337.20	393.60	449.60	506.00	562.00	618.40	674.40	730.80	786.80	843.20
	BC	8.70	2.22	1.48	1.48	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74	0.74
5	PC	98.00	114.00	172.00	228.00	286.00	342.00	400.00	456.00	514.00	570.00	628.00	684.00	742.00	798.00	856.00
	BC	14.80	11.10	7.40	7.40	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70	3.70
9	PC	66.00	124.60	189.40	249.80	312.40	373.20	437.20	497.60	561.60	622.00	686.00	746.40	810.40	870.80	934.80
	BC	33.30	19.98	13.32	13.32	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66	6.66
13	PC	67.86	129.91	197.67	257.92	327.38	389.73	457.29	519.64	587.20	649.55	717.11	779.47	847.02	909.38	976.93
	BC	48.10	28.86	19.24	19.24	9.62	9.62	9.62	9.62	9.62	9.62	9.62	9.62	9.62	9.62	9.62
17	PC	71.11	135.42	206.53	270.84	341.96	406.27	477.38	541.69	612.80	677.11	748.22	812.53	883.64	947.96	1019.07
	BC	62.90	37.74	25.16	25.16	12.58	12.58	12.58	12.58	12.58	12.58	12.58	12.58	12.58	12.58	12.58
21	PC	74.47	140.93	215.60	281.87	356.53	422.80	497.47	563.73	638.40	704.67	779.33	845.60	920.27	986.53	1061.20
	BC	77.70	46.62	31.08	31.08	15.54	15.54	15.54	15.54	15.54	15.54	15.54	15.54	15.54	15.54	15.54
25	PC	78.27	148.44	226.67	296.84	375.11	439.33	517.55	585.78	664.00	732.22	810.44	878.67	956.89	1025.11	1103.33
	BC	92.50	55.50	37.00	37.00	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50	18.50
29	PC	107.76	151.52	213.73	303.91	385.84	455.87	537.84	607.82	689.50	759.79	841.55	911.73	993.51	1063.69	1145.47
	BC	107.30	64.38	42.92	42.92	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46	21.46
33	PC	114.07	157.67	242.80	314.93	400.27	472.40	557.73	629.87	715.20	787.33	872.67	944.80	1030.13	1102.27	1187.60
	BC	122.10	73.26	48.84	48.84	24.42	24.42	24.42	24.42	24.42	24.42	24.42	24.42	24.42	24.42	24.42
37	PC	120.34	162.98	251.87	325.56	414.84	488.93	577.82	651.91	740.80	814.89	903.78	977.87	1066.75	1140.84	1229.73
	BC	136.90	82.14	54.76	54.76	27.38	27.38	27.38	27.38	27.38	27.38	27.38	27.38	27.38	27.38	27.38
41	PC	126.69	168.49	260.93	336.58	429.42	505.67	598.91	673.96	766.40	842.64	934.89	1010.93	1103.38	1179.62	1271.87
	BC	151.70	91.02	60.68	60.68	30.34	30.34	30.34	30.34	30.34	30.34	30.34	30.34	30.34	30.34	30.34
45	PC	133.00	174.00	270.00	348.00	444.00	522.00	618.00	696.00	792.00	870.00	966.00	1044.00	1140.00	1218.00	1314.00
	BC	166.50	99.90	66.60	66.60	33.30	33.30	33.30	33.30	33.30	33.30	33.30	33.30	33.30	33.30	33.30
49	PC	139.31	179.51	278.87	359.02	458.58	538.53	638.09	718.04	817.60	897.55	997.11	1077.27	1176.62	1256.58	1356.13
	BC	181.30	108.78	72.52	72.52	36.26	36.26	36.26	36.26	36.26	36.26	36.26	36.26	36.26	36.26	36.26
53	BC	145.62	185.82	288.14	370.04	473.16	555.67	658.14	740.93	843.20	925.11	1028.22	1110.13	1213.24	1295.16	1398.27
	BC	196.10	117.66	78.44	78.44	39.22	39.22	39.22	39.22	39.22	39.22	39.22	39.22	39.22	39.22	39.22
57	PC	151.93	190.53	297.20	381.07	487.72	571.60	678.27	762.13	868.80	952.67	1059.33	1143.20	1249.87	1333.73	1440.40
	BC	210.90	126.54	84.36	84.36	42.18	42.18	42.18	42.18	42.18	42.18	42.18	42.18	42.18	42.18	42.18
61	PC	158.24	196.04	306.27	392.05	502.31	588.13	698.35	784.14	894.40	980.22	1090.44	1176.27	1286.49	1372.31	1482.53
	BC	225.70	135.42	90.28	90.28	45.14	45.14	45.14	45.14	45.14	45.14	45.14	45.14	45.14	45.14	45.14
65	PC	164.56	201.56	315.33	403.11	516.89	604.67	718.44	806.22	920.00	1007.78	1121.55	1209.33	1323.11	1410.89	1524.67
	BC	240.50	144.30	96.20	96.20	48.10	48.10	48.10	48.10	48.10	48.10	48.10	48.10	48.10	48.10	48.10

Table 16

THE FOLLOWING TABLE LISTS PORTABLE UNIT COSTS, AND BUSSING COSTS FOR 100 STUDENTS

NUMBER OF TEAMS

MILES		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	PC	118.40	173.40	224.00	273.60	311.80	373.80	436.43	449.60	504.00	562.00	618.40	674.40	730.80	786.80	843.20
	BC	37.00	18.50	12.56	9.62	7.40	6.66	5.92	5.18	4.44	3.70	3.70	3.70	2.96	2.96	2.96
5	PC	178.00	179.00	232.00	280.00	319.00	381.00	444.00	456.00	514.00	570.00	626.00	684.00	742.00	798.00	854.00
	BC	185.00	92.50	62.00	46.10	37.00	33.30	29.60	25.90	22.20	18.50	18.50	18.50	14.80	14.80	14.80
9	PC	198.20	237.40	292.40	339.20	378.20	441.00	517.20	558.30	581.60	622.00	686.00	746.40	815.40	870.80	934.80
	BC	333.00	166.50	113.22	86.50	66.60	59.94	53.28	46.62	39.96	33.30	33.30	33.30	26.64	26.64	26.64
13	PC	237.07	266.47	324.27	369.07	466.53	471.67	554.18	629.99	587.28	649.55	717.11	779.47	847.02	889.38	976.93
	BC	481.10	240.50	163.56	125.06	96.20	80.58	70.90	67.34	57.72	48.10	48.10	48.10	38.48	38.48	38.48
17	PC	273.64	298.53	359.73	398.53	505.47	502.33	591.16	669.78	758.56	677.11	748.22	812.53	903.64	947.96	1019.07
	BC	629.00	314.50	213.66	163.56	125.80	113.22	100.64	88.06	75.48	62.90	62.90	62.90	50.32	50.32	50.32
21	PC	320.27	361.33	387.20	438.80	544.40	533.00	628.13	710.67	809.80	784.67	779.33	845.60	920.27	985.53	1063.38
	BC	777.60	388.80	264.18	202.62	155.40	139.86	126.32	108.78	93.24	77.70	77.70	77.70	62.16	62.16	62.16
25	PC	380.11	395.11	485.33	541.56	583.23	563.67	665.11	751.55	853.00	734.22	810.44	878.67	956.89	1025.11	1103.33
	BC	925.00	462.50	314.50	240.60	185.00	166.50	148.00	129.50	111.00	92.50	92.50	92.50	74.00	74.00	74.00
29	PC	419.49	429.86	522.27	580.86	622.27	594.33	702.82	792.44	900.20	990.55	941.55	911.73	993.51	1063.69	1145.47
	BC	1073.00	536.50	364.62	279.08	214.60	193.14	171.68	150.22	128.76	107.30	107.30	107.30	85.84	85.84	85.84
33	PC	487.60	462.67	561.20	620.13	661.20	777.60	739.07	833.33	947.40	1041.67	872.67	944.80	1030.13	1102.27	1187.60
	BC	1221.60	610.80	415.44	317.46	244.20	219.78	195.36	170.94	146.52	122.10	122.10	122.10	97.68	97.68	97.68
37	PC	529.73	562.02	600.13	659.47	700.13	822.40	776.04	874.22	994.60	1092.74	903.76	977.87	1066.75	1140.84	1229.73
	BC	1369.60	684.80	465.46	355.64	273.60	246.42	219.24	192.06	164.88	136.90	136.90	136.90	109.52	109.52	109.52
41	PC	606.11	590.81	639.07	699.71	739.07	867.20	813.02	915.11	1041.80	1143.99	1270.58	1010.93	1103.38	1179.42	1271.87
	BC	1217.60	758.50	515.78	394.47	303.40	273.06	242.72	212.38	182.04	151.70	151.70	151.70	121.36	121.36	121.36
45	PC	489.60	529.00	780.00	734.00	779.00	912.00	850.00	956.00	1089.00	1195.00	1328.00	1044.00	1140.00	1218.00	1314.00
	BC	1869.00	932.50	568.10	432.60	333.00	299.70	266.40	233.10	199.80	166.50	166.50	166.50	133.20	133.20	133.20
49	PC	775.40	737.20	821.40	777.29	998.11	936.88	1135.87	998.89	1136.20	1249.11	1385.42	1495.33	1176.62	1256.58	1356.13
	BC	1813.00	906.50	618.42	471.28	362.60	326.34	290.08	253.82	217.56	181.30	181.30	181.30	145.04	145.04	145.04
53	PC	875.80	780.40	872.40	985.42	1047.22	1081.60	1189.73	1037.78	1183.40	1297.27	1442.84	1556.67	1702.29	1295.16	1398.27
	BC	1961.60	980.50	667.74	509.88	392.20	352.98	313.76	274.54	235.32	196.10	196.10	196.10	156.88	156.88	156.88
57	PC	921.47	962.73	1045.60	1014.13	1098.32	1046.40	1243.60	1305.20	1230.60	1348.33	1500.27	1618.00	1769.93	1313.73	1440.40
	BC	2109.60	1054.50	717.06	544.34	421.80	379.62	337.44	295.26	253.08	210.90	210.90	210.90	168.72	168.72	168.72
61	PC	1022.64	960.64	1097.47	1062.84	1149.44	1091.20	1297.47	1454.53	1277.80	1399.44	1557.69	1679.33	1837.58	1959.22	1482.53
	BC	2257.00	1128.50	767.38	586.82	451.40	406.26	361.12	315.98	270.84	225.70	225.70	225.70	180.56	180.56	180.56
65	PC	1380.11	1087.11	1151.23	1111.55	1200.55	1401.67	1351.23	1514.67	1325.00	1450.56	1615.11	1740.67	1905.22	2030.78	2195.33
	BC	2405.00	1202.50	817.70	625.30	481.00	422.50	364.00	326.70	240.60	240.50	240.50	240.50	192.40	192.40	192.40

Table 17

THE FOLLOWING TABLE LISTS PORTABLE UNIT COSTS, AND BUSSING COSTS FOR 200 STUDENTS

		NUMBER OF TEAMS														
MILES		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	PC	186.40	234.40	297.60	366.20	403.60	447.00	479.20	547.20	616.00	623.00	685.60	747.60	810.20	872.20	934.80
	BC	74.00	37.00	25.14	18.50	14.80	12.58	11.10	9.62	8.88	7.40	7.40	6.66	5.92	5.92	5.18
5	PC	205.00	244.80	312.00	368.00	418.00	459.00	492.00	560.00	632.00	635.00	700.00	762.00	827.00	889.00	954.00
	BC	370.00	185.00	125.80	92.50	74.00	62.90	55.50	48.10	44.40	37.00	37.00	33.30	29.60	29.60	25.98
9	PC	344.60	373.00	432.00	474.80	542.40	576.60	677.20	678.40	766.80	735.00	811.20	882.00	958.20	1029.00	1105.20
	BC	666.00	333.00	226.44	166.50	133.20	113.22	99.90	86.58	79.92	66.60	66.60	59.94	53.28	53.28	46.62
13	PC	426.40	470.33	493.33	532.93	605.60	635.53	747.96	738.13	835.60	822.67	868.62	943.33	1025.84	1100.56	1183.07
	BC	682.00	481.00	327.04	240.50	192.40	163.54	144.30	125.06	115.44	96.20	96.20	86.58	76.96	76.96	67.34
17	PC	513.89	519.60	604.40	591.07	668.58	694.47	818.71	767.87	984.40	997.33	926.04	1004.67	1093.49	1172.11	1260.93
	BC	1258.00	629.00	427.72	314.50	251.60	213.86	188.70	163.54	150.96	125.80	125.80	113.22	100.64	100.64	88.06
21	PC	586.33	581.73	673.20	722.67	732.27	753.40	889.47	857.60	973.20	1072.00	983.47	1066.00	1161.13	1243.67	1338.80
	BC	1554.00	777.00	528.36	388.50	310.80	264.18	233.10	202.02	186.48	155.40	155.40	139.86	124.32	124.32	108.78
25	PC	682.60	685.22	742.00	790.22	901.67	936.67	960.22	1083.11	1042.00	1146.67	1271.33	1127.33	1228.78	1315.22	1416.67
	BC	1850.00	925.00	629.00	462.50	370.00	314.50	277.50	240.50	222.00	185.00	185.00	166.50	148.00	148.00	129.50
29	PC	783.18	751.98	892.93	857.78	977.13	1009.73	1030.98	1161.69	1110.80	1221.33	1355.07	1188.67	1296.42	1386.78	1494.53
	BC	2146.00	1073.00	729.64	536.50	429.20	364.82	321.90	278.98	257.52	214.60	214.60	193.14	171.68	171.68	150.22
33	PC	918.80	869.80	959.20	925.33	1052.40	1082.80	1101.73	1240.27	1179.60	1296.00	1438.80	1252.20	1364.07	1458.33	1572.40
	BC	2442.00	1221.00	830.28	610.50	488.40	415.14	366.30	317.46	293.04	244.20	244.20	219.78	195.36	195.36	170.94
37	PC	1033.55	941.07	1035.47	1104.04	1128.07	1155.87	1172.49	1318.84	1502.28	1370.67	1522.53	1644.80	1431.71	1529.89	1650.27
	BC	2738.00	1369.00	930.92	684.50	547.60	465.46	410.70	355.94	328.56	273.80	273.80	246.42	219.04	219.04	191.66
41	PC	1154.02	1072.82	1206.27	1181.62	1203.53	1228.93	1458.35	1397.42	1592.60	1445.33	1606.27	1734.40	1895.33	1601.44	1728.13
	BC	3034.00	1517.00	1031.56	758.50	606.80	515.78	455.10	394.42	364.08	303.40	303.40	273.06	242.72	242.72	212.38
45	PC	1280.00	1214.00	1290.00	1258.00	1446.00	1497.00	1546.00	1476.00	1683.00	1520.00	1690.00	1824.00	1994.00	1673.00	1806.00
	BC	3330.00	1665.00	1132.20	832.50	666.00	566.10	499.50	432.90	399.60	333.90	333.00	299.70	266.40	266.40	233.10
49	PC	1451.24	1364.60	1463.20	1474.40	1533.64	1584.20	1633.04	1554.58	1773.40	1943.22	1773.73	1913.60	2092.67	2232.53	1883.87
	BC	3626.00	1813.00	1232.84	906.50	725.20	616.42	543.90	471.38	435.12	362.60	362.60	326.34	290.08	290.08	253.82
53	PC	1633.51	1450.20	1574.40	1560.80	1621.25	1671.40	1721.29	1630.84	1863.80	2041.64	1857.47	2003.20	2191.33	2337.07	2525.20
	BC	3822.00	1911.00	1333.48	980.50	764.40	650.74	573.30	509.86	470.64	382.20	382.20	352.58	313.76	313.76	274.54
57	PC	1826.80	1614.93	1752.00	1805.47	1812.43	1596.00	2061.63	2028.27	1954.20	2139.07	2342.13	2092.80	2290.00	2441.60	2638.80
	BC	4218.00	2109.00	1434.12	1054.50	843.60	717.06	632.70	548.34	506.16	421.80	421.80	379.62	337.44	337.44	295.26
61	PC	2031.11	1789.09	2020.53	1901.29	2012.26	2097.33	2196.13	2125.69	2428.00	2237.89	2492.18	2182.40	2388.67	2546.13	2752.40
	BC	4514.00	2257.00	1534.76	1128.50	902.80	767.38	677.10	586.82	541.68	451.40	451.40	406.26	361.12	361.12	315.98
65	PC	2246.44	2061.22	2126.67	2174.22	2340.00	2198.67	2306.67	2223.11	2540.00	2336.11	2602.22	2803.33	2487.33	2650.67	2866.00
	BC	4810.00	2405.00	1635.40	1202.50	962.00	817.70	721.50	625.30	577.20	481.00	481.00	432.90	384.80	384.80	336.70

children are transported.[1] For example, transporting a given number of children to a clinic containing two teams will be half as expensive as transporting children to a clinic with only one team, and transporting children 25 miles by bus will be five times as expensive as transporting children 5 miles.

Unfortunately, these simple linear relationships do not exist when considering the costs associated with a portable clinic. It is necessary to study the model in Appendix C in order to understand the influence of each cost factor entering into the total cost presented in the tables.

It may be noted from the table that, in general, the optimum or least cost way of delivering dental services to children in the rural areas would be to transport them by bus to a large clinic containing many teams. If 10 dental teams were available in one clinic (each team composed of one dental nurse, two dental assistants) then even if a school containing 100 children were 65 miles away from this clinic, it would only cost $2.40 per child every six months or $4.80 per year for each child to average four visits to the clinic.[2] In comparison, it would cost over $20.00 per child per year to take the service to the school from a home base located 65 miles away.

Unfortunately, a clinic containing 10 such dental teams could treat over 15,000 children per year and the geographical area required

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[1] A graphical analysis was done of the results presented in the tables but the mathematical formula used would readily indicate the conclusions drawn here.

[2] See Table 15.

to enclose this number of children would have greater than a 65 mile radius for all but the cities of Saskatoon and Regina.[1]

Even transporting children 65 miles for a dental appointment may prove unpopular with parents and, for the purposes of this study, it has been assumed that acceptable travel distances for either staff or children would be less than 50 miles in one direction or 100 miles total per day. It has also been assumed that service areas should be designed such that, where possible, at least 1,000 children between the ages of three and twelve should be located within the service area, providing sufficient yearly work for one dental nurse and two dental assistants.[2]

As a result of these criteria, which were proposed by the Saskatchewan Department of Public Health, 52 dental service areas were designated in Saskatchewan.[3] Each dental team assigned to the various areas was composed of one dental nurse and two dental assistants. The following table lists the number of clinics justifying various numbers of dental teams based upon the population of children in each of the 52 service areas.

Over 80 percent of the proposed clinics contain only one or two dental teams and this of course severely restricts the choice of

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[1] See Regional Totals of Children in Appendix D of A Proposal for a Dental Program for Children in Saskatchewan.

[2] Actually one dental team could care for over 1,500 children and in the case of as few as 1,000 children, the second dental assistant may be hired on a part-time basis.

[3] Ibid., p. 49.

Table 18

THE NUMBER OF DENTAL TEAMS DESIGNATED FOR FIFTY-TWO HOME BASE DENTAL CLINICS IN SASKATCHEWAN

Number of Clinics	No. of Dental Teams Per Clinic
27	1
15	2
5	3
5	4+

an optimum transportation system. Generally speaking, where only one dental team is located in a certain area, it is half as expensive to set up a clinic in the schools as it is to transport children by bus. For two teams bus transportation is cheaper for distances under 17 miles, but for children located further than this portable clinics should be considered. For three or more teams, transportation by bus is seen to be less expensive.

Clearly the table can only be used as a guideline for decisions. Bus transportation may not be readily available in certain areas; the bus station may be located in such a manner that four trips instead of two are required to transport one load of children from a certain school. Space may not be available in certain schools for a portable clinic and other options such as a mobile clinic may have to be examined in contrast to bus transportation.

For large city areas the table of costs is not applicable since bus companies will often charge a flat rate for services, and the staff

will of course not be able to claim for travelling expenses, nor will lost time due to travel be applicable while working within the city limits.

It must be noted when examining the cost tables, that these costs would only be incurred for delivering services to less than 25 percent of the population of eligible children in Saskatchewan. All other children would be located within the town or city where each of the 52 clinics are located, and for these children transportation costs could be virtually eliminated by setting up portable clinics within the schools where space was available. The only costs associated with these clinics would be the staff time required to set up or take down the dental equipment.

The location of dentists in Saskatchewan is such that they have their practice either in or near to each of the 52 towns and cities designated as home base clinics for the dental nurse teams. Under these circumstances, extensive recruiting or training of dentists would not be required to provide the work requiring a dentist's skill, as children could be referred to the local private dentist who would be paid on either a fee-for-service or contractual arrangement. If a salaried dentist were hired, he would have to do extensive travelling in order to cover the children being treated by six dental nurse teams. As a result of this time spent in travelling, the costs of using salaried dentists in the rural areas would be approximately equal to the fee-for-service costs associated with using the local dentist.[1]

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[1] Research and Planning Branch, Department of Public Health, Saskatchewan, A Proposal for a Dental Program for Children, p. 45.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

Several dental studies have been reviewed, and an attempt has been made to consolidate the results obtained from four major experiments carried out by the Canadian Dental Corps, the Prince Edward Island Department of Health, the Dental Manpower Development Centre in Louisville, Kentucky, and the Department of Public Health in Saskatchewan. These studies provided the basis for establishing and selecting the mix of dental personnel which would deliver high quality dental care to children in Saskatchewan in the most economical manner.

A comparison was made between various transportation alternatives which focused on the problem of either moving dental personnel and equipment to schools or moving children to central treatment sites. Each of these alternatives were examined with the objective of determining the least-cost method of providing dental services within the constraints imposed by the geographical distribution of the population in Saskatchewan.

Conclusions

The first conclusion is that the least-cost staffing pattern for providing dental services to children between the ages of three and twelve is estimated to consist of a dental nurse working with two

dental assistants in a three-chair clinic. One dentist could supervise up to six teams composed of such auxiliaries and provide the necessary dental care beyond the capabilities of the dental nurse. Supervision in this case would mean the dentist would be responsible for the clinical standards, educational upgrading, and the hiring and firing of clinical staff, but not necessarily located on the same site as the dental nurse. In this way dental nurses may refer children to private practitioners and one supervising dentist may spend more of his time visiting and assisting a greater number of dental nurses.

The cost of such a service without including travel time, or administrative costs, is estimated to be $20.00 per year for each child receiving care. This is less than 50 percent of fee-for-service charges for a similar program using private dentists.

Educational costs for staff were not included in any of the studies reviewed. There is some evidence that the training costs of a dental hygienist, dental nurse or dentist will be approximately equal when divided by the normal number of years in the work force.[1]

The second conslusion is that the optimum transportation system may, depending on local conditions, consist of a variety of combinations of permanent and portable dental clinics, mobile clinics and the transporting of children by bus. If greater than three dental nurse teams

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[1]The educational costs for a dental hygienist and dentist have been broken down in Nova Scotia's Council of Health report, Interim Report of the Council's Task Force on Dental Care, Clarence L. Gosse, Chairman (Halifax: Nova Scotia Council of Health, 1972), p. 43.

are located in a particular site, transporting children by bus to the clinic would normally be the least expensive alternative. Unfortunately, there may be no bus available to provide this service, and the full-time employment of a bus specifically for this duty may be more expensive than some other alternative. Where space is available in schools, a portable dental clinic would be less costly than a mobile dental van.

A computer program is included in Appendix D which calculates portable dental clinic costs and the costs associated with transporting children by bus. The variables entered into this program may be changed easily in order to adapt to local costs and conditions.

Recommendations

Cost Considerations

The least-cost dental staffing pattern as established in this study may in fact be more expensive than some other alternative which has not been attempted but for which the technology already exists. There is sufficient evidence inthe literature to suggest that preventive dental techniques can eliminate all but a small percentage of restorative needs.[1] Some of the latest dental techniques, such as the coating of a child's teeth with a protective layer of plastic (commonly referred to as a fissure sealant), may be carried out by dental auxiliary with minimum training. This would not only prove less costly, but cause less trauma to the child.

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[1] R.D. Fraser, Selected Economic Aspects of the Health Care Sector in Ontario, A Study for the Committee on the Healing Arts (Toronto: Queen's Printer, 1970), p. 130.

The total cost of a dental care program paid for by government will, of course, depend upon the total number of children to be covered. Given its budgetary constraints, the Government of Saskatchewan initially restricted the scope of the delivery program to children between the ages of three and twelve; however, it is strongly recommended that dental care continue to be provided to a child throughout his teen years if the maximum benefits are to be derived from investment in a dental program. The rationale behind this recommendation may be found by examining the high caries attack rate in children between the ages of thirteen and eighteen and realizing that this factor could undo much of the effort put forth for the younger child.[1]

Finally, in order to contain the costs associated with a comprehensive children's dental program, a great deal of coordination and cooperation will be necessary between the departments of education and health. Schools should be discouraged from selling soft drinks and candy during break periods. In addition, teachers should become well informed about dental health and where possible participate in passing this knowledge on to children and parents.

Mobile and Portable Clinics

Mobile clinics such as used in Oxbow must be introduced with caution. Declining child populations may leave sufficient space within

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[1] From a personal interview with Dr. P. MacRae, Professor of Dentistry at the University of Alberta, and from a review of the literature pertaining to the caries attack rate in children through the teen years.

the schools to set up portable dental clinics, eliminating the requirement for more expensive mobile units. If such mobile dental clinics are necessary, they should be staffed for efficient patient handling. In Oxbow, each dental nurse and dentist had one dental assistant and only one chair. As shown in the Canadian Dental Corps study, two chairs for each dental nurse and dentist would have allowed a more efficient utilization of professional staff.

Mobile units seldom have sufficient waiting room space for parents and children; and for large units, because of the general lack of sound barriers, one crying child can affect all the children within the clinic. Proper ramp space must be available and the units should be capable of quick connections to plumbing, electricity and telephone lines. A self-propelled mobile unit is more flexible but also has less space. A mechanical failure may mean a great deal of staff time may be lost if alternate dental facilities are not available. One advantage of the mobile unit in Oxbow was the great deal of attention received by the trailer itself, encouraging parents to take an interest in the program.

A portable dental unit may be more economical than a mobile unit but also has certain disadvantages. The dental equipment is generally heavy and delicate. Moving would probably best be done by professional movers who would not have to dismantle the equipment completely if it was carried in large vans. The main piece of equipment too heavy to be carried by dental staff would be a modern dental chair. Portable chairs are available but are less satisfactory in

terms of flexibility and ease of adjustment. The decision as to which type of equipment to use will probably depend on staff preferences. In any case, the loss of staff time due to changing locations will be minimized by a planned routine for each move and sufficient spare equipment to allow for breakages or loss.

Clerical Staff Requirements

The requirement for clerical or secretarial staff will largely depend upon the size of the dental clinics. None of the dental studies covered in this paper have examined the role of the secretary receptionist. Although this category of staff may make the clinic run more smoothly and efficiently, there was no documented evidence of the extent to which output would be increased by adding clerical personnel. Because one secretary in Oxbow was able to handle the secretarial duties of one dentist and two dental nurses, it is hypothesized that a secretary working in any smaller clinic would not be active on a full-time basis unless she were trained to perform some duties other than clerical (such as the cleaning of dental instruments). Because these tasks would, no doubt, be considered outside the job description of a secretary, either dental assistants should alternate in performing clerical duties or large clinics should be established which can effectively utilize clerical personnel.

The Dental Nurse

Recent statements from the dental profession in various provinces have made it clear that the introduction of this type of dental auxiliary will be strongly opposed by dentists. Saskatchewan has a

particularly low dentist to population ratio and perhaps this fact strongly influenced the acceptance of the dental nurse. Without this auxiliary many more years of training dentists would be required before a dental program for children could begin. Formal reports from the dental profession in Saskatchewan endorsed the Oxbow type of program where the dental nurse was under direct supervision of the dentist, but they were opposed to any system whereby the dental nurse would work independently.

It is recommended that newly graduated dental nurses be given fairly close supervision by dentists only until they develop confidence and are able to establish their own quality control mechanism. Once a high quality of care can be monitored by the profession of dental nurses, the New Zealand experience has demonstrated that supervision or control by dentists is unnecessary.

Dentists in Private Practice

It has been documented in this paper that a dentist in private practice may substantially reduce the average costs of the services he provides by expanding to a four-chair clinic and employment four dental auxiliaries. There has been a great deal of evidence from surveys conducted by the Canadian Dental Association that dentists who employ many auxiliaries are able to substantially increase their net income; however, there is little or no evidence to suggest that the savings which are obtained are passed on to the general public in terms of reduced fee schedules. This is not surprising, given the fact that all fee-setting, self-governing professions tend to emulate

the behaviour of a profit maximizing monopolist or cartel; however, it is argued that a significant reduction in costs could inhibit the rate at which fees are adjusted in an upward manner. It is suggested that governments should recognize that in the short run, an increased output of dental auxiliaries will improve the net income position of dentists practicing in the entrepreneurial sector of the industry. This implies that the supply of auxiliaries must be sufficient to meet both the public and private sector demands unless certain constraints are imposed on the mobility of this type of labour. Given the potential demand for dental auxiliaries that appears to be arising in other provinces, it is suggested that in the short run the Province of Saskatchewan should:

(1) through the use of bursaries and other contractual agreements attempt to hold all graduating auxiliaries within the province; and

(2) encourage dental auxiliary summer students from other provinces to work in Saskatchewan during their school holidays, so that top people may be approached about future employment in Saskatchewan

Clearly some joint effort must be made at the national level to ensure that an adequate supply of auxiliaries will be made available to meet overall Canadian demands.[1]

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[1] Recruitment from New Zealand and Great Britain should be considered. The New Zealand dental nurse operates with more independence than the British auxiliary but tends to use less modern techniques and equipment. It is felt that the British dental nurse would be the better selection for recruitment purposes.

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APPENDICES

APPENDIX A

OUTPUT MEASURES IN DENTISTRY

The following measures are often used in dental literature to describe the output of dental services provided by dentists and dental auxiliaries. Each must be accompanied by a description of the mix of services provided and the activities of various dental staff members before comparisons or conclusions can be based on these output measurements.

Relative Value Units

The Relative Value System was developed for the Canadian Dental Association in order to give Canadian dentists a scientific formula to use in making up their dental fee schedules, and eliminate many of the inequities which were present in the existing fee schedules.[1] The basic formula for the Relative Value Unit is: Time (T) (measured in 15 minute units) x Responsibility Factor (R) = Relative Value Unit (R.V.U.). As a measure to be used for fee determination,[2] the Relative Value System has merit, but as a measure of output many distorations may occur. Because a responsibility factor is included, any fee charged for services

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[1]Canadian Dental Association, Transactions 1965, Appendix A, "Relative Value Method of Fee Determination," (Toronto: Canadian Dental Association, 1965), p. 38.

[2]The suggested fee is determined by multiplying the relative value unit by a conversion factor "f" which converts the basic unit to dollars.

carried out by a dental auxiliary[1] is less per unit of time than the more complex services carried out by a dentist. When productivity of a particular dental team is to be measured and compared with another, however, this same responsibility factor included in the relative value unit requires that the mix of activities performed by the teams is equivalent, in order to obtain a meaningful relationship between the two sets of calculations. It may be argued that instead of tabulating R.V.U.'s, only the T factors should be totalled to give a productivity measure. Unfortunately, this is seldom done, and even the relative T factors may be suspect.[2] As long as mix of dental services performed by dental teams under study is equivalent, the Relative Value System may be used to give approximate output measurements for productivity comparisons.

Time Units

The Time Unit System was devised in Prince Edward Island to

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[1] K.D. Fraser suggests that anything with an "R" factor reading of 1.25 or less is within the competence of a lesser trained dental health nurse; e.g., his chapter on "Child Dental Care: Dental Health Nurse Versus Dentist" (Selected Economic Aspects of the Health Care Sector in Ontario) (Toronto: Queen's Printer, 1970), p. 125.

[2] If the time factors in the Relative Value System are inaccurate, then, in order to gain the equivalency required for comparison, care must be taken to assure the relative value units are not distorted for any particular dental team by an overvalued or undervalued procedure. R.G. Romcke found, for example, that under the circumstances existing in one clinic, examinations and extractions were highly overvalued in the R.V.U. system. If one dental team carried out a few more of these procedures than another, their productivity may appear to be higher than it actually was. See page 9 of the Prince Edward Island Dental Manpower Study (Charlottetown: Department of Health, 1972) for Romcke's analysis.

compensate for the possible distortions of the Relative Value System.[1] Each time unit represents work requiring one productive minute of the study dentist's time.

The Time Point System is used by the Royal Canadian Dental Corps,[2] and is simply a weighted Time Unit System.[3] When the productivity of a particular dental clinic is to be measured, the total number of the various dental procedures is calculated and multiplied by their appropriate time unit value in order to obtain a composite measure of output. In this way, the number of time units is actually a proxy for output, and if the mix of services provided is also given, the time units provide a basis for measure of output available within one particular study. Because a particular dentist with a special technique may be more productive in a particular procedure than another, and because, as mentioned earlier, the Relative Value Unit and other time unit systems have not been found to be accurate in various types of practices, the use of the time units should not be used to compare output between practices.

Gross Income

Gross income is sometimes used as a measure of a dentist's productivity.[4] It could be used to compare the changes in output of

[1] R.G. Romcke, The Prince Edward Island Dental Manpower Study, p.9.

[2] K.M. Baird, G.B. Shillington and D.H. Protheroe, "Pilot Study on the Advanced Training and Employment of Auxiliary Dental Personnel in the Royal Canadian Dental Corps: Preliminary Report." The Journal of the Canadian Dental Association, XXVIII, No. 2 (1962), p. 633.

[3] The weighting factor was not described in the literature.

[4] Bruce A. McFarlane, Dental Manpower in Canada, p. 172.

particular dental practices if the fees were uniform and the case mix was equivalent. Unfortunately, the fees are not uniform and, in fact, tend to increase as the number of auxiliaries in the practice increase.[1] This increased fee would of course inflate any productivity measurement of a dentist with several auxiliaries working with him when compared to a dentist working alone. Because the mix of dental services is not presented with the gross income figures in the most comprehensive Canadian dental income statistics[2] it is impossible to check on the usefulness of gross income as a proxy for output.

Net Income

Net income figures are also an unreliable productivity measurement. There is no evidence to suggest that a dentist charges his own fee for a procedure carried out by an auxiliary, but there is proof, as already pointed out, that average fees tend to increase with the number of auxiliaries in a dental practice. If all auxiliaries are fully employed in the provision of dental services, the net income of a practice with four auxiliaries may be higher than that of a practice with three auxiliaries because of the higher fee and not necessarily because of increased output.

Patient Visits

The number of patient visits may be a valuable measure of output if the average length of appointment were the same in the studies

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[1]Bureau of Statistics, Canadian Dental Association, Survey of Dental Practice, 1968 (Toronto: Canadian Dental Association, 1968), p. 116.

[2]Ibid.

being compared and the mix of services provided was given. If the mix of services is not given, an increase in the total output of a dental practice may be related to the dentist using more auxiliaries and concentrating on preventive measures which they can carry out independently. This would not mean the dentist's own productivity has increased.

Patients Treated

The total number of patients treated in a year may be used as a measure of output if the mix of services is provided. However, patients may vary widely in their dental needs, and a simple tally of the number of patients treated would not provide enough information for a comparative study of one dental practice with another.

APPENDIX B

College of Dental Surgeons of Saskatchewan

Bylaws, 1970

Article XI Dental Hygienists and Auxiliaries

#7 A dental hygienist may perform any duties delegated to her by a dentist who must be responsible for the standards and quality of dental treatment rendered to the patient. These duties shall not include oral diagnosis and treatment planning, prescribing of drugs, injection of drugs, cutting of hard or soft tissue, fabrication of prosthetic and orthodontic appliances requiring the skill and knowledge of a qualified dentist.

#8 A dental hygienist shall not establish or attempt to establish professional relations with respect to the practice of dental hygiene with any patient or intended patient except in the name, on behalf of, and with the consent of the dentist by whom she is employed.

#12 The duties of a certified dental assistant shall not include

a) examination, oral diagnosis, and treatment planning
b) prescribing of drugs
c) injection of drugs
d) cutting of hard and soft tissue
e) fabrication of prosthetic and orthodontic appliances requiring the skill and knowledge of a qualified dentist
f) deep sealing
g) placing any restorations
h) taking of any impressions other than those involved in the production of study models
i) the application of any periodontal pack.

APPENDIX C

A Cost Comparison of Setting up a Portable Dental Clinic Versus Transporting Children to a Dental Clinic by Bus

The costs associated with either transporting children to a clinic or sending out a dental team to a particular rural school will mainly vary with the number of miles of travel involved, the number of dental teams[1] who are either travelling or who exist in the particular clinic to which children are being taken, and the number of children requiring treatment. The following model explains the determination of costs associated with a portable dental clinic. The general equation may be placed in the form:

$$TCP\ (X,T) = SU + TS + FC + TCT + FA + LLC$$

where TCP (X,T) is equal to the total cost of a portable dental clinic consisting of "T" teams treating "X" students.

SU = The set up and take down costs of a portable clinic in terms of professional time lost. Each move of a portable clinic is estimated to take two hours to set up and two hours to take down. It is assumed that a mobile van type of vehicle will be used which will allow the transportation of equipment without having to completely disassemble everything for each move. The cost will equal:

$$4 \times SC \times T$$

were 4 = 4 hours - the time to set up and take down equipment

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[1] A dental team for the purposes of this section will be defined as one dental nurse and two dental assistants.

SC = the salary cost for one hour of the dental team's work.

T = the number of dental teams involved.

TS = The vehicle costs involved with the dental team travelling out to the portable clinic and back on the day of set up. This cost will equal:

2 x D x CT x XCTT

where:

2 = a factor to account for the team travelling out to the clinic and back

D = the distance the team must travel in one direction in order to reach the clinic

CT = the vehicle costs per mile for 2 teams

XCTT = a factor which is introduced because one vehicle can only carry 2 teams. If the number of teams = 4 then XCTT will equal 2.

FC = The food costs for a team on the day they move and set up and take down equipment. Each day away from their home base, field staff in Saskatchewan are entitled to claim for meals. In this case only lunch would be claimed for since they would be expected to leave after breakfast and get back to their home base for supper. This cost will equal:

P x T x F

where:

P = the number of persons on a team

T = the number of teams

F = the food cost of one lunch ($2.00) may be claimed in Saskatchewan

TCT = The vehicle costs for dental teams going out to treat students.

This cost will equal:

TF x 2 x D x CT x (XCTT)

where:

TF - the number of days required for "T" dental teams to treat "X" students.

$$= \frac{X}{(NC-TL)T} \times V + .6 \text{ rounded to lower whole number}$$

where:

X = the number of students to be treated

NC = the number of students able to be treated in one day by one team.

TL = the number of students unable to be treated each day because of staff travelling time.

= TLL x the average number of children able to be treated in an hour.

where TLL = the number of hours spent in travelling

T = the number of teams involved

V = the average number of visits required for each child every six months.

.6 = a number added to account for the fact that if a portion of a day is involved in the answer up to this point, up to .4 of a day could have been used in the day of the set up of the clinic to treat children. Any time over this would require an additional day's travel.

2 = A factor to allow for costs of travel to and from the portable clinic each day.

D = The number of miles out to the portable clinic.

CT = Vehicle costs per mile for 2 teams.

XCTT = Factor to account for the number of teams - as above.

FA = Food allowance costs. Each day the team travel out of town to the portable site, it will be allowed the cost of one lunch. This cost will equal:

TF x P x T x F

where:

TF = the number of days as described above

P = the number of persons on one team

T = the number of teams

F = the cost of one lunch

LLC = The dollar value of the team's time spent in travelling. This is a measure of the output or treatment costs lost by having the dental personnel move rather than having the children transported to the home base of the dental team. Similar to the set up and take down costs above, this cost is not really a direct expense but is more indirect in that, because of this lost time, additional personnel will have to be hired in order to perform the work which was not covered because of travel. In the Prince Edward Island experiment, the working day was cut from 8 hours to 5½ hours because of the 2½ hours travelling time required each day to get out to the rural schools. This cost will equal:

TF x SC x T x TLL

where:

TF = number of days of travel as above

SC = the hourly salary cost of one team

T = the number of teams

TLL = the number of hours spent in travelling

= 0 if the distance to be travelled is less than 7 miles[1]

= $\frac{D}{45}$ x 2 if the distance to be travelled is greater than 7 miles

where:

D = distance travelled in miles

45 = 45 miles per hour average travelling speed

2 - a factor to account for travelling to and from the clinic

This next model is used to describe the transportation of children by bus to a dental clinic:

$$BC(X,T) = \left(\frac{X}{CS \times T} \times V + .998\right) \times 2 \times D \times B$$

where:

BC(X,T) is equal to the total cost of transporting "X" children to a clinic containing "T" dental teams.

X = the number of children to receive dental care

CS = the number of children treated by one team in 1½ hours. This time is arbitrary, but if a bus load of children are brought to a clinic, it is unlikely that either the clinic, the children, teachers, or parents will desire a waiting time much over an hour for an appointment or after an appointment.

T = the number of teams in the clinic

V = the average number of visits each child must make to the clinic

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[1] The seven miles is an arbitrary figure but given because workers within cities often have to travel seven miles or more to work and do not get paid for time spent in this manner. In any case, because 45 miles an hour is used as an average travelling speed, short distances would not amount to significant lost labour time.

every six months.

.998 = a number to account for the fact that a bus cannot make a portion of a trip.

2 = a number to account for the bus going to and from the clinic each time it brings a load of children from the school. If a bus is not located in or near the school receiving dental care, a bus may have to be sent from the clinic site. This would mean a factor of 4 should be used instead of 2.

B = the cost of hiring a bus by the mile.

The variables which have been entered into the computerized version of the preceeding model are as follows:

B = $ 0.35 = cost per mile for transportation by bus. This will vary from location to location and among bus sizes but the average quoted from several companies in Saskatchewan was $0.37 per mile.

CT = $ 0.10 = the transportation costs for provincial vehicles (cars or station wagons) in Saskatchewan.

SC = $11.00 = hourly salary and fringe benefit costs for one dental nurse and two dental assistants broken down as follows: dental nurse = $5.00 per hr.
dental assistants = $3.00 per hr.

F = $ 2.00 = The lunch costs allowed to Saskatchewan's provincial employees when they are field staff working away from home base.

NC = 18 = the average number of dental appointments for one dental team (one dental nurse and two dental assistants) in one day. The average number of

appointments per day for one dental nurse and one dental assistant in Oxbow was 13. The range was from zero to 18. With an extra dental assistant, the dental team will probably be able to handle 18 appointments per day.

CS = 4 = the average number of appointments made or children treated in 1½ hours. This was derived from the maximum waiting time for children for each appointment.

V = 2 = the average number of appointments per child for each six-month recall examination. This was taken from the Oxbow data which indicated an average of four appointments per year.

P = 3 = the number of personnel on the dental teams being considered. In this case, it is one dental nurse and two dental assistants.

APPENDIX D

```
FORTRAN IV G COMPILER(21)      MAIN          03-07-73     15:41.33     PAGE 0001

0001                 INTEGER TEAMS,X
0002                 REAL NC,LCC,LLC
0003                 DIMENSION TEAMS(15)
                C    B = BUSSING COSTS FOR STUDENTS PER MILE
                C    CS = CHILDREN TREATED BY 1 TEAM IN 1.5 HOURS
                C    CT = TRAVELLING COSTS PER MILE FOR 2 DENTAL TEAMS
                C    CTT =NUMBER OF VANS REQUIRED TO TRANSPORT TEAMS.
                C    D = DISTANCE OF TRAVEL FOR BUS OR TEAM
                C    F = FOOD COST PER PERSON FOR LUNCHES
                C    FC = FOOD COSTS FOR TEAM WHEN SETTING UP PORTABLE EQUIPMENT
                C    LOC = LIVING OUT COSTS FOR ONE TEAM  FOR ONE DAY
                C    NC = NUMBER OF STUDENTS WHICH CAN BE SEEN IN ONE DAY BY ONE TEAM
                C      P= NO. OF PERSONNEL ON 1 TEAM
                C    SC = SALARY COST OF ONE TEAM PER HOUR
                C    T = NUMBER OF TEAMS
                C    TF = TIME FACTOR FOR TREATING X STUDENTS BY T TEAMS
                C    TL= NUMBER OF STUDENTS UNABLE TO BE TREATED IN A DAY
                C    TLL= TIME LOST BY STAFF DUE TO TRAVEL
                C    TS = TRAVEL COSTS FOR SET UP AND TAKE DOWN OF PORTABLE EQUIPMENT
                C      V= NO. OF VISITS FOR EACH 6 MONTH PERIOD
0004                 DO 41 N=1,15
0005              41 TEAMS(N)=N
0006                 READ(1,3) B,CT,SC,F,LCC,NC,CS,V,P
0007              3  FORMAT(9F5.2)
0008                 WRITE(3,25)
0009              25 FORMAT('0','THE VARIABLES FOR THE FOLLOWING TABLES ARE',5X,'B',4X,
                    2'CT',4X,'SC',5X,'F',3X,'LOC',4X,'NC',4X,'CS',5X,'V',5X,'P')
0010                 WRITE(3,26)B,CT,SC,F,LCC,NC,CS,V,P
0011              26 FORMAT('0',44X,9F6.2)
0012                 DO 50 X=10,100,10
0013                 CALL TABLE (X,B,CT,SC,F,LCC,NC,CS,V,P,TEAMS)
0014              50 CONTINUE
0015                 DO 42 X=100,400,100
0016                 CALL TABLE (X,B,CT,SC,F,LCC,NC,CS,V,P,TEAMS)
0017              42 CONTINUE
0018                 STOP
0019                 END

$RUN *LOAD* 1=*SOURCE* 3=*SINK*
15:41.40

THE VARIABLES FOR THE FOLLOWING TABLES ARE      B     CT     SC      F    LOC     NC     CS      V      P

                                              0.37   0.10  11.00   2.00  35.50  18.00   4.30   2.00   3.00
```

APPENDIX D -- Continued

```
FORTRAN IV G COMPILER(21)       TABLE           03-07-73    15:41:35    PAGE 0001

0001            SUBROUTINE TABLE (X,B,CT,SC,F,LUC,NC,CS,V,P,TEAMS)
0002            REAL NC,LCC,LLC
0003            INTEGER CTT,TF,T,D,X,TEAMS
0004            DIMENSION TCP(40),15),BC(4C3,15),          TEAMS(15)
0005            WRITE(3,21)X
0006         21 FORMAT('1',24X,'THE FOLLOWING TABLE LISTS PORTABLE UNIT COSTS, AND
               1 BUSSING COSTS FOR',1X,I3,2X,'STUDENTS')
0007            WRITE (3,22)
0008         22 FORMAT('0',49X,'NUMBER OF TEAMS')
0009            WRITE (3,23)TEAMS
0010         23 FORMAT('0',1A,'MILES',15(6X,I2))
0011            DO 30 D=1,65,4
0012            DO 40 T=1,15
0013            XD=D
0014            IF(D.LE.7)TLL=0.0
0015             IF(D.GT.7)TLL=((XD/45)*2)
0016            TL=TLL*3.0
0017            XA=X
0018            XNC=NC
0019            XT=T
0020            CTT=XT/2+.6
0021            XCTT=CTT
          C     TRAVEL COSTS FOR SET UP AND TAKE DOWN
0022             TS=2*D*CT*XCTT
          C     FOOD COSTS FOR SET UP AND TAKE DOWN
0023            FC =P*T*F
          C     TIME FACTOR FOR TREATING X NUMBER OF STUDENTS
0024            TF=((XX/((XNC-TL)*XT))*V)+.6
0025            IF(TF.LT.1)TF=1
          C     TRAVELLING COSTS FOR TEAM TO TREAT STUDENTS
0026            TCT=TF*2*D*CT*XCTT
          C     FOOD ALLOWANCE COSTS
0027            FA=TF*P*T*F
          C     SET UP AND TAKE DOWN COSTS
0028            SU=4*SC*T
          C     LOST LABOUR COST DUE TO TRAVEL
0029            LLC=TF*SC*T*TLL
          C     TOTAL COST FOR PORTABLE DENTAL UNIT
0030            TCP(X,T)=SU+TS+FC+TCT+FA+LLC
          C     BUSSING COST FOR STUDENTS
0031            R=((XX/(CS*T))*V)+.CUP
0032            IP=R
0033            XIP=IP
0034            BC(X,T)=XIP*2*D*R
0035         40 CONTINUE
0036            WRITE(3,31)(TCP(X,KK),KK=1,15)
0037            WRITE(3,32)D,(BC(X,KK),KK=1,15)
0038         32 FORMAT(' ',2X,I2,2X,'PC',15(1X,F7.2))
0039         31 FORMAT('0',6X,'PC',15(1X,F7.2))
0040         30 CONTINUE
0041            RETURN
0042            END
```